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THE FRANKLIN INSTITUTE.

The Telepost.

[*The Report of the Franklin Institute, Through Its Committee on Science and the Arts, on the Telepost: A New System of Automatic Telegraphy, Devised by Patrick B. Delany, of South Orange, N. J. Sub-Committee: E. Alex. Scott, Chairman; Carl Hering, Wm. O. Griggs, Richard L. Binder.*]

[No. 2427.]

The United States Patents submitted by the inventor, Patrick B. Delany, Nos, 709,752, 720,004, 720,233, 790,193, 800,364, and 802,740, describe, respectively, means for handling receiving tape; means for utilizing the static charge of the circuit; receiving tape for chemical telegraphs; transmitting and receiving apparatus; telegraphic tape recording apparatus, and an electro-magnetic perforator.

The patents cover the latest development in automatic telegraphy, the purpose of the inventor being to adapt the system to existing business conditions and to cheapen the cost of the service. The system embraces both the Electro-magnetic and Electro-chemical methods of receiving messages and transmitting them by perforated tapes.

The use of perforated tapes, or ribbons of paper, is almost as old as the art of telegraphy. Bain, a Scotchman, was the pioneer in Automatic telegraphy, especially of the chemical method. A Philadelphian, nearly ninety years ago, made the discovery that an electric current could be used to make a mark, but Bain first used the principle for recording telegraphic signals. Wheatstone, an Englishman, followed with an ink recorder, and having a better machine for punching the tapes than Bain's and with better financial support, the Wheatstone system superceded Bain's in England. In America, Bain competed with Morse in the early days of commercial telegraphy, but did not remain long in the field.

The most notable use of the chemical system was by the Automatic Telegraph Company, which built lines in 1871 from New York to Washington and Charleston, with offices at Philadelphia and other intermediate points. It continued in business for about three years with fair success, when Jay Gould obtained control of the stock and sold it to Vanderbilt and Western Union interests. Delany, Edison, Johnson and some other well known electrical engineers, were prominent in that company, Mr. Delany being its general manager. He has never wavered in his belief that automatic telegraphy must eventually become universal. One by one he has overcome the electrical and mechanical difficulties which beset the system.

In the thirty-five years which have elapsed since the extinction of the Automatic Telegraph Company, there has been no increase of speed in the hand transmission of the Morse lines. On the contrary, the operating force has become less efficient, as is shown by the statement of the president of the Western Union Telegraph Company, who fixes the average speed of transmission of messages over the lines of that company at fifteen words a minute, not more than sixty per cent. of the average in 1875.

The principal difficulty encountered by all high-speed telegraphs, and which gave the old Automatic line the most trouble, is "retardation," or the "static charge," or "capacity," of the circuit. After a signal has been sent and the circuit has been opened at the sending end, a current continues to flow from the receiving end until the accumulated static charge has run out. This additional current leaves a record on the receiving tape and makes the message illegible. As each signal is followed by this residual current, the spaces between the dots and dashes

on the record are filled up, the words run together. This difficulty increases in proportion to the length of the lines, as the "capacity" is proportionate to its surface, and also to the character of the insulation covering the wire. The capacity of submarine cables is very great, and in practice the line is not fully discharged between signals, but merely varied in amount of static charge as messages are being sent.

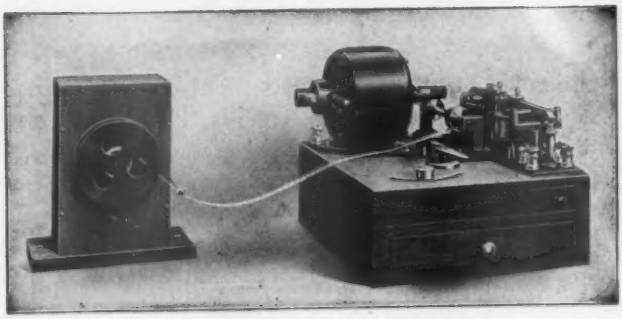
In a former patent which came before the Institute in 1896, Mr. Delany described a method of sending dots only into the line, the dashes being received as a double line of dots, thus distinguishing them from the dots of the alphabet, which were received in a single line. This method had two advantages; first, the line received less current from the battery and the static charge was not so great as if dashes had been sent; second, the dots in the double line were readily distinguished as dashes, even though they ran together.

The most important of the patents submitted in the present application is United States Patent 720,004, which deals with the objectionable static charge. In this patent Mr. Delany describes a method of utilizing the "capacity" of the circuit in producing the record on the receiving tape. Dots only are sent into the line. The sending tape is so punched that immediately after the dot signal is sent, a reverse current is sent from the opposite pole of the battery, which neutralizes the static charge on the line. If, however, a dash is intended, the reverse current is not applied to the line until a sufficient interval has elapsed to permit the static charge to make a mark upon the receiving tape; the disturbing element is thus made to do work.

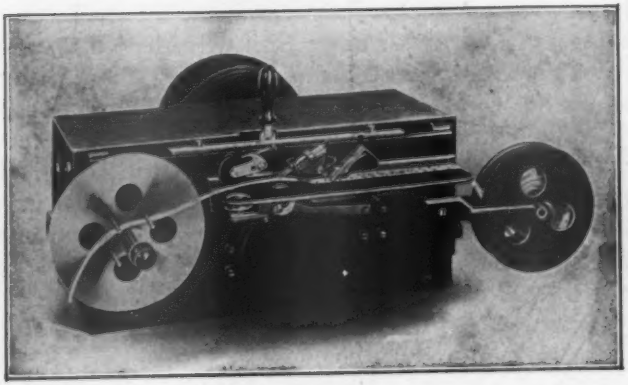
As the capacity of electric circuits varies with the length and size of the wire, capacity of instruments in circuits, character of insulation, and other conditions, it might happen that a circuit would have too small a capacity to produce a dash. The patent provides that in such cases capacity may be added to the desired amount by the introduction of condensers or similar means, such as a parallel circuit, so that the chemical method may be used on short as well as long lines.

The capacity of the line as a distributing factor having been removed, it is a short step to increase the speed and distance over which chemical telegraphs may be operated. So long as any current reaches the receiving station, the tape will record it, although

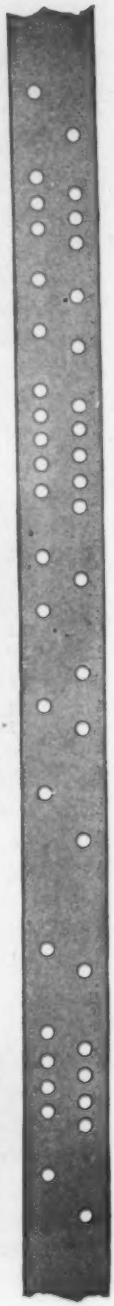
Keyboard



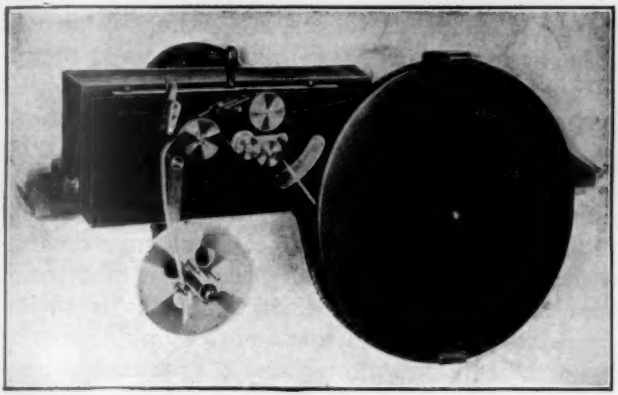
Perforator



Transmitter

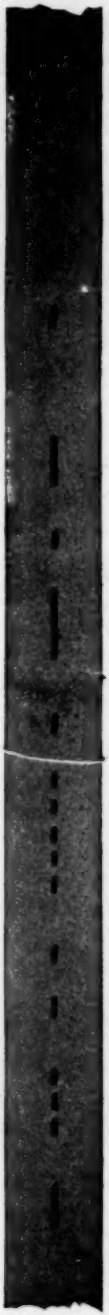


Perforated tape



Receiver

Transcriber



Received tape

with a lighter shade as the current decreases. The interruptions which interfere with the Electro-magnetic system, due to bad insulation, electric and magnetic storms, are entirely eliminated from the chemical system, which has no moving parts at the receiving end operated by the line current. It is only necessary that the circuit shall be clear enough for the operators to get intelligible Morse signals over it, to receive messages on the tape with absolute clearness.

The transmitting and receiving apparatus are described in United States Patent No. 790,193, which combines some recent improvements with prior patents to make the system more completely automatic and improve its efficiency. Among these improvements are electro-magnetic starting and stopping devices by which the movement of the transmitter may be automatically arrested, or started, by current from the distant station; or the receiving instrument at the distant station may be automatically started or stopped by current from the transmitting station. The instruments at both stations therefore start and stop simultaneously, or may be stopped at the will of the operator at either station. The running out of the transmitting tape automatically stops the receiving instrument. This feature keeps the operators in close touch with each other, and facilitates the transaction of business.

The transmitting and receiving offices are connected with each other over a circuit normally equipped with Morse instruments, and the operators communicate with each other by the Morse system. When messages are to be sent the transmitting operator places the punched tape, rolled up on a block, on a spindle, with one end of the tape between the rolls which draw it past the transmitting fingers. He then notifies the receiving operator, who places a roll of chemical tape on the receiver. By throwing one switch the Morse set of instruments is disconnected, the automatic instruments are put on the circuit, and the apparatus at both stasions is set in action. Should anything go wrong, the receiving operator can instantly stop the transmitter at the sending station.

One difficulty with receiving tapes has been that they expand when placed in the chemical solution after having been rolled up on a reel for use. This expansion tears the tape and unfits it for use. To remedy this Mr. Delany passes the tapes through crimping rolls, which corrugates them in different styles, longitudinal,

transverse, in straight or wavy lines, which permits of their being wound as firmly as may be necessary for handling without disturbing the coil, and allows for saturation by the fluid without rupturing the tape. This is covered by United States Patent No. 720,233.

United States Patents Nos. 800,364 and 802,740 cover claims for improvements in Electro-magnetic recorders and perforators for transmitting tapes, such as may be used for transmission in automatic telegraphy, or such perforations of, or record upon the tape as may be actuated from a distance through the medium of an electric circuit, and which may be used as the final record, or be used for transmitting through another circuit.

The latter of these is an improvement upon a former patent, and is designed to adapt the apparatus for use with a single polarity of current. Two polarized relays with biased armatures are used instead of a single relay with a neutral armature. One acts by the movement of its armature to open the circuits of the punch magnets; the second polarized relay controls the first. The punch magnets are alternately energized for a brief period only, while the armature of one relay is passing from its back stop to the contact which energizes the other relay. The punches therefore do not impede the movement of the tape.

This apparatus is designed particularly to be operated from a distant point. Business houses connected with the central telegraph office by wire, as many are now connected, may send their message by the Morse system and have it received as a perforated tape. This would be used in transmission over the high-speed line to destination, where it would be received chemically. Or the tape could be used in place of an operator to send the message over a branch line to a Morse operator, at a speed suited to his ability to receive it.

Where messages pass through repeating stations, they may be received on a perforated tape at a speed several times greater than by a Morse operator, and retransmitted over another circuit. This method would greatly facilitite the handling of business from branch lines and relieve the overburdened trunk lines. Press dispatches may thus be sent to local points at a very small cost, a single tape sufficing for several circuits.

In connection with this apparatus Mr. Delany has invented a key by which the Morse characters can be made at a very much

higher rate of speed than by the ordinary Morse key. The operator moves the lever horizontally to the left, closes the circuit and makes a dash. He releases it, and a vibrating arm, weighted at the end, opens and closes the circuit, making dots until the operator again moves the lever for a dash. Very rapid writing can be done in this way without fatigue.

The Committee saw the apparatus covered by these patents in operation on two occasions, and tested the speed of transmission of the chemical system at twelve hundred words a minute. The record on the tape was perfect, much more uniform than could possibly have been made by hand transmission. The same tape transmitted at a slower speed was received on the Electro-magnetic recorder as a punched tape, and to the ear of an experienced operator was perfectly clear and intelligible.

The commercial importance of Mr. Delany's completed system of high-speed automatic telegraphy, and particularly of his elimination of that bane of telegraphy, the static charge, or retardation, becomes more and more evident as its application to existing conditions is considered. High speed upon long or short lines is now assured. The carrying capacity of a line is made sixty-fold greater than hand-worked lines. Expert service is reduced to a minimum. Errors in transmission are eliminated. Line maintenance is decreased in proportion to increased speed. As a result of these conditions the cost of service can be made so low that the volume of business should be very great.

The Institute is of the opinion that the invention described in Mr. Delany's patent, United States Patent No. 720,004, in connection with the improvements covered by the other patents referred to, by which the capacity effect of the circuit is used to assist in forming the record, is worthy of the highest award, and the Elliott Cresson Gold Medal is therefore conferred upon Patrick B. Delany.

Attest: WM. H. WAHL, *Secretary.*

Philadelphia, April 1, 1908.

History, Manufacture and Analysis of Maple Products.

By Albert P. Sy, Ph.D.

Maple sirup and sugar belong to North America; they are not produced in any other country, and only in limited parts of this continent, namely in the New England and northern Middle-West States, and in Canada. We are, therefore, dealing with products whose early history must be associated with the history of the country and with the history of the original Americans, the Indians. In nearly all the earlier accounts of the Indians given to us by travellers, discoverers and adventurers, we also find accounts of maple sirup and sugar. In some cases, it is true, these accounts are by no means complete; but it must be remembered that these early writers were, as a rule, not scientists, but for the mose part missionaries or adventurers.

The question as to who discovered the sweet maple sap and the fact that sirup and sugar can be made from it has been much debated. At first thought it appears quite probable that the Indians, with their natural shrewdness would not be long in discovering maple sap; they depended largely upon the products of the forest for their food. It has been argued* that the Indians belonged to the stone age and had no metallic vessels in which to evaporate the sap to produce sirup or sugar. But these were not absolutely necessary; the sap evaporates spontaneously; sirup or sugar is found on wounded maple trees; spontaneous evaporation from wooden or bark vessels would leave sugar; freezing the sap would concentrate the sugar, and this latter fact was known to the Indians.† They also knew how to evaporate the sap in clay or bark vesesls by dropping hot stones into it.‡ Writing about the Iroquois Indians, Morgan says:§ "The Iroquois have long been in the habit of manufacturing sugar from the maple. Whether

*Morgan: League of the Iroquois, p. 187.
†Forestry Bulletin, U. S. Dept. Agr., No. 59, p. 5.
‡"Capture of John Smith," 1755-59.
§"League of the Iroquois," L. H. Morgan, p. 193.

they learned the art from us or we from them may be a difficult question; although the former would seem the more likely, from the want of suitable vessels among them for boiling." Ely,* after quoting from writings of early explorers, says: "This shows that the Indians understood and made use of the sap of different maples before the advent of Europeans; it was an established industry among them before the discovery of the Mississippi. * * * Lafitau and Bossu, writing at different periods, agree explicitly in ascribing the origin of maple sugar to the Indians." C. H. Jones† says the early Vermont settlers learned the art of maple sugar making from the Indians.

Mr. Frank H. Severance, Secretary of the Buffalo Historical Society, in a communication to the writer, says it is his "understanding that the Indians made sirup and sugar from the maple before the coming of the whites. They did not have metal vessels until they received them from Europeans. At the time of the discovery of America, the Indian was in the Stone Age. He made vessels of stone and wood, but whether these were used in boiling maple sap I cannot say. The earliest mention of the use of maple sap that I know of, speaks of it as a thing original with the Indians. I think the Europeans learned from the Indians in this matter."

Professor Cowell, Director of South Park Conservatory, Buffalo, in a letter to the writer, says: "I have heard that tale about the Indians teaching the early settlers the art of sugar making, but I have not been able to find satisfactory evidence of it. I do not believe they had conveniences for sugaring off. They undoubtedly knew that the sap is sweet, and probably they drank it in its crude state." Mr. David Boyle, of the Provincial Museum, Toronto, writes: "I have made a good deal of inquiry about the question with regard to Indian knowledge of maple sugar and sirup. I don't believe the Indians ever knew anything about maple sugar or sirup until the arrival of the French in Quebec, and it is my belief that it was taught to the Indians by a French doctor named Saussure, early in the 16th century. The Indians no doubt knew that maple sap is sweet, but beyond that, it was impossible for them to take any steps towards the manufacture of

*"Garden and Forest," Vol. 4, p. 207.
†"Expansion," I, 5, p. 5.

either sirup or sugar. They had no means of tapping trees, and no way of reducing the sap to any thickness."

As far as tapping is concerned, it seems to the writer that the Indians are just as likely to have used the old method of cutting gashes into the trees as the early white settlers. To reduce the sap, there are of course other methods than boiling in metal vessels. It surely does seem that the Indians must have known that maple sap on concentration yields a sugar. The writer can remember making the observation as a boy of ten years, that when hickory wood was used for camp fires, from the ends of these logs projecting from the fire there would distil the sap, the water coming off as steam, leaving a gummy mass of sugar.

T. Wheeler states* that the Indians used maple sap four thousand years ago: they caught it in troughs of wood. Many myths and legends relating to the maple tree are found among the Indians. For the Chippewas†, an Ovid-like metamorphois of Nishosha, the magician, took place, and in a few seconds he stood a tall and stiff maple tree. By some of the Indians, a certain month of the year was called the "sugar month," or "sugar moon," indicating that sugar-making was aboriginal. Another evidence of antiquity of Indian sugar-making is in their ancient religious festivals instituted to the maple. One of these is the "Maple Dance,"‡ the sugar festival in the spring, when old and new sugar were mingled by the medicine man, and the aid of Great Spirit invoked.

The Ojibwa word for maple sugar is zeence-zee-bah-quod, meaning, "drawn from wood or tree;" another name is "*Enin-ah-tig Weesh-ko-bun*, which means "man, wood sugar." There are a great many Indian names for the maple tree, sugar tree, maple sugar, and sugar, but with one exception, not one of these has as yet been found which resembles or relates to any European name for sugar. In the Cree language the French white sugar is called by the special name "so-kaw," probably a corruption of the French *sucre*.

Lescarbot, a Paris lawyer, who came to New France in 1606,

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*"Garden and Forest," Vol. 6, p. 120.

†"Garden and Forest," Vol. 4, p. 207.

‡Among the Iroquois it was called "O-ta-de-none-ne-o-Na-Wata." See Morgan "League of the Iroquois," p. 187.

writes* about the Indians: "S' ils sont pressez de soif ils ont l' industrie de succer les arbres, d'ou distille une douce et forte agréable liqueur, comme je l' ai experimenté quelque fois." Lescarbot here undoubtedly refers to maple sap, for he describes† "erables" (Acer rubrum). Pierre Boucher (1663) describes the maple‡ and says, "quand on entaille ces Herables au Printemps el en degoutte une quantité d' eau, qui est plus douce que de l' eau detrempée dans du sucre." Robert Boyle, in 1663, wrote: "There is in some parts of New England a kind of tree whose juice that weeps out of its incisions, if it be permitted slowly to exhale away the excess moisture, congeals into a sweet substance."

Père Christien Le Clercq, a missionary (1675) writes:§ "Dans le temps que les arbres étoient en sève quelqu' un de nous se trouvait indisposè, ou ressentoit quelque debilité de coeur nous faisons une fente dans l'ecorce d'un erable qui distilloit une eau sucree qu'on amassoit avec un plat d'ecorce, et qu'on beauvait comme une remede souverain."

He also states,¶ "Par une ouverture assez petit, qu'on fait avec la hache dans érable, on en fait distillé des six ou douze pots Ce qui m'a paru essez remarquable dans l'eau d'érable, c'est que si à force de la faire bouillir on la reduit au tiers, elle devient un veritable syrop, qui se durcit à peu prés comme le sucre, et prend une couleur rougeâtre. On en forme des petits pains q'on envoie en France par vareté, et qui dans l'usage sert bien souvent au defaut du sucre Francais." He states explicitly that they made sugar by boiling the sap. Unfortunately he does not mention the kind of vessels used.

Joutel (1684), a companion of LaSalle, writes:** "La Providence nous fournissoit une espèce de manne pour adjouter à notre bled d'Inde, laquelle manne estoit d'un suc que les arbres jettent dans cette saison et notamment les erables." He then describes in detail the tapping of trees and collecting of sap, and says, "laquelle etant bouillie, à force de diminuer devient du sucre.

*Lescarbot, Vol. 4, p. 865; see also "Garden and Forest, 4, p. 171.

†Lescarbot, Vol. 3, p. 852.

‡"Historie Veritable et Naturalle de la Nouvelle France," p. 44.

§"Establissment de la Foy," Vol. 1, p. 252.

¶LeClercq: Nouvelle Relation de la Gaspesie, p. 124.

**Vovage depuis les Illinois jusque à Missilimakinak, p. 509.

Nous nous servions de cette eau pour fair bouillir notre bled d'Inde ou 'sagimité,' ce qui lui donnait un assez bon goust c'est à dire un peu sucré. Il semble que la Providence fournit à tout ces comme il n'y a point de cannes à sucre dans ces cantons les arbres en fournissent, du moires j' en ai veu qui estoient excellent."

La Hontan (1684)* describes the tapping of trees and collection of sap. He says: "On fait de cette sêve du sucre et du sirop si precieux qu'on n'a jamais trouvé de reméde plus propre à fortifier la poitrine."

Père S. Rasles (S. J.), in 1689 wrote:† "Les femmes s' occupent à la recevoir dans des vases l'ecorce, lorsque ces arbres la distillent; elles la font bouillir, et elles trient un assez bon sucre. Le premier qui se tire est toujours le plus beau."

L. Hennepin‡ (1698) speaks of the maple sap and its use as a drink; also that they boiled it and obtained a reddish sort of sugar, much better than ordinary cane sugar.

In the writings of Père Lafitau (1700) we find the following§ description of the Indians making sugar from maple sap: "Elles font ensuite bouillir cette eau sur le feu qui en consume tout le phlegme, et qui epaisset le reste en consistence de syrop, ou même de pain de sucre, selon le degré et la quantite de chaleur qu'ils veulent lui donner." (See Plate I.) He also says that the French work it better than the savages,*from whom they have learned to make it.* He says that the sugar almost always has a little burnt taste. Ely¶ explains this burnt taste by saying that it would naturally result from the primitive Indian method of evaporating sap by dropping red-hot stones into the sap contained in bark or wooden vessels. Pinkerton** gives a full account of maple trees, maple sirup and sugar among the North American Indians.

In 1756, the Indians were using brass kettles for evaporating maple sap. James Smith, an English boy of eighteen, who was

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*LaHontan, Vol. 2, p. 61.

†Rasles "Letters Edifiantes," Vol. 4, p. 83.

‡"New Discovery," Pt. II, p. 147.

§"Moeurs des Sauvages Ameriquains," II, p. 83.

LaBeau, in "Adventures de C. Le Beau, Tome 1, p. 45, uses the identical words, having evidently copied them from Lafitau.

¶"Garden and Forest," 4, p. 183.

**Voyages and Travels in All Parts of the World," Vol. 13, p. 359.

captured and adopted by the Indians, writing of his experiences,* describes in detail how the Indians made sirup and sugar by evaporating maple sap in two brass kettles holding fifteen gallons each. He says that they commonly used this sugar by putting it into bears' fat until the fat was almost as sweet as the sugar itself, and into this mixture they dipped their roasted venison.† Smith re-

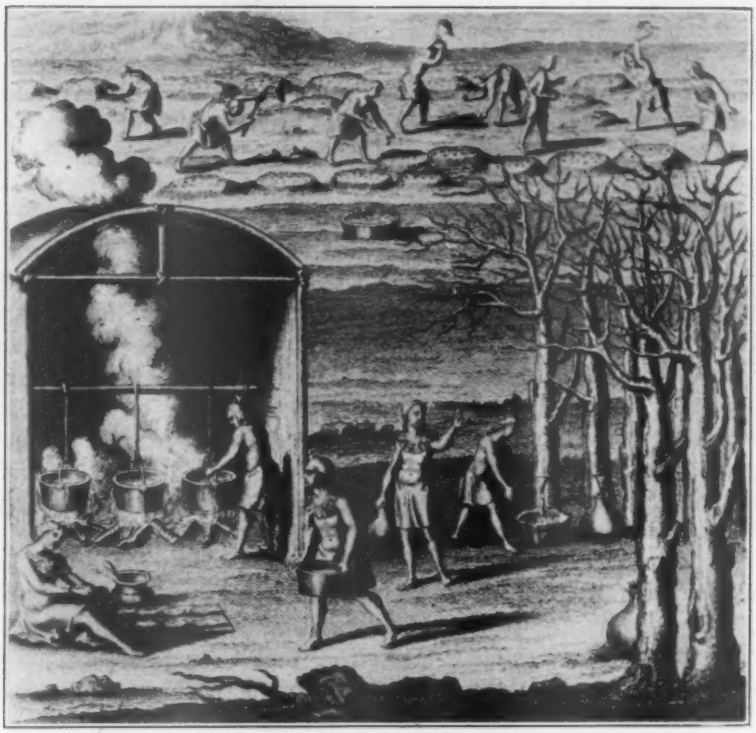

Plate 1. Indians tapping trees and evaporating sap making maple sugar. From Lafitau, II p. 154 (about 1700 A. D.)

lates‡ that in 1757 they had no kettles with them, and they concentrated the sap by allowing it to freeze and throwing away the ice. After several freezings the water remaining in the vessels changed color, became brown and very sweet.

*"Captivity of James Smith," p. 36.

†This shows that even the savages knew something about a balanced diet. This mixture furnished fat carbohydrates and protein.

‡Ibid, p. 68.

M. Bossu, a captain in the French navy writing* about the Indians (1756) collecting sap, says: "Qu ils font bouillir jusqu'à ce qu' il soit réduit en sirop lequel étant rebouilli, se convertit en sucre un peu roux, et semblable à la manne de calabre. Lez Francois, etablis aus Illinoiz, *out appris des suavages la façon d' en faire.*" In his "Nouveaux Voyages dans l'Amerique Septrentionale," p. 237, Bossu describes a beverage which the Indians made from green corn by expressing the juice, and then adding maple sugar. This they used as a tonic. The white women used it for washing their faces, for their complexion. Mention is made of maple sugar by Carver,† Henry,‡ Lancourt;§ and nearly all travelers in North America during the 18th century mention maple sugar.

One of the earliest and most complete descriptions of the maple industry is one by Dr. Rush.¶ He mentions the fact that Mr. Jefferson, afterward President, never used any other than maple sugar on his table. Dr. Rush thought that eventually we would produce enough maple sugar so as not to need any cane sugar, made by slaves in the West Indies. He says: "A material part of the general happiness which Heaven seems to have prepared for mankind will be derived from the manufacture and general use of maple sugar. I cannot help contemplating a maple sugar tree without a species of veneration, for I behold in it a happy means of rendering commerce and slavery of African brethren in sugar islands as unnecessary."

Early in the 19th century, the maple industry was described by Père Sagard,** and N. Denys.††

BOTANY AND GEOGRAPHY OF THE MAPLE.

Considerable confusion exists with reference to the classification of the different species of the genus *Acer*. Linné named the

*Nouveaux Voyages aux Indes Occidentales." Part I, Lettre 9, p. 164.

†"Travels Through Interior of North America, 1766."

‡"Travels and Adventures in Canada and Indian Territories," 1760.

§"Travels Through U. S. of N. Am."

¶Trans. American Philosophical Soc., 1792.

**"The Grande Voyange du Pays des Hurons," p. 102.

††"Historie Naturalle de Peuples, Animaux, Arbres et Plantes de l' Amerique Septentrionale," 2, p. 316.

silver or soft maple *A. saccharinum;* this was the species with which he was most familiar (the hard maple does not grow in Europe, except very rarely) and as its sap is as sweet as that of our hard maple, he called it *saccharinum.* Confusion of species names was started by Wangenheim in 1787, by calling the sugar or hard maple *A. saccharinum,* thinking that Linné meant the sugar maple by this name. Botanists who to-day follow Wangenheim's classification use the name *A. dasycarpum* for the soft or silver maple, due to Errhart (1789). In 1785, Marshall called the sugar maple *A. saccharum,* and the silver maple *A. glaucum;* since Marshall's *A. glucum* is older than Ehrhart's *A. dasycarpum,* the former should be used if Linné's A. saccharinum is discarded.

The correct classification, as adopted by careful writers and botanists to-day,* is *Acer saccharum,* hard, rock or sugar maple; *Acer saccharinum,* soft or silver maple; *Acer rubrum,* red maple.

All the species of *Acer* have sweet sap, and while the hard maple furnishes by far the largest part of maple sugar, the sap from the other species is also occasionally used, especially the soft or silver maple. The sugar maple is a stately forest tree; it usually produces a great many seeds, which are ripe in the fall of the year; these seeds germinate and grow readily, even in very shady places, producing after a while a very dense growth. If left to itself, this would never be very productive for sugar making, and a dense young grove must be thinned out.† The maple is an excellent tree for decorative effect; it has a beautiful shape and is a good shade tree in summer. In autumn the beautiful landscapes seen in some parts of the country are due to the brilliant leaf colors of the maple. These colors are due to the disintegration of chlorophyll and the presence of xanthophyll and erythrophyll; sugar maple leaves in autumn range in color from orange, gold, crimson to scarlet.

For sugar making, the range of the maple is limited to the New England States, New York, Pennsylvania, Ohio, Lake States, and Southeastern Canada (St. Lawrence and Lake regions). It does not flourish in the Old World and is rarely found there.

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*"Maple Sugar Industry," W. F. Fox, Bulletin 59, Bur. Forestry, U. S. Dept. Agr. Also private communication from Prof. Cowell.

†Bulletin 59, Bur. Forestry, U. S. Dept. Agr., p. 29.

1850	1860		1870		1880		1890		1900	
Sugar lbs.	Sugar lbs.	Sirup gals.	Sugar lbs.	Sirup gals.	Sugar lbs.	Sirup gals.	Sugar lbs.	Sirup gals.	Sugar lbs.	Sirup gals.
6,349,357	9,897,781	16,253	8,894,302	12,023	11,261,077	128,091	14,123,921	218,252	4,779,870	160,918
1,298,863	2,255,012	43,833	1,830,704	16,884	2,731,945	79,712	2,124,515	81,997	441,870	41,588
795,525	1,006,078	15,307	399,800	2,326	878,793	13,017	558,674	33,632	192,990	27,174
93,542	306,742	32,679	160,805	28,470	153,334	82,006	84,537	71,818	5,500	16,024
50,796	44,259	2,377	14,266	168	44,092	2,173	8,617	1,437	4,930	948
0,357,484	10,816,419	131,843	6,692,040	46,048	10,693,619	266,390	10,485,623	457,658	3,623,540	413,159
2,326,525	2,767,335	114,310	1,545,917	39,385	2,866,010	14,067	1,651,163	154,650	1,429,540	160,297
.....	.....	.....	490,606	20,209	310,866	28,696	177,724	19,032	141,550	14,874
47,740	63,281	2,404	70,464	374	176,076	2,043	156,284	10,21	264,160	5,825
1,227,665	938,103	99,605	245,093	11,460	85,693	7,518	26,991	3,468	19,310	1,677
2,197	3,455	8,088	419	5	2,496	334	210	134	.....	.....
4,588,209	3,345,508	370,512	3,469,128	352,612	2,895,782	495,839	1,575,562	727,142	613,990	923,519
2,921,192	1,541,761	292,908	1,332,332	227,880	235,117	242,084	67,329	180,702	51,900	179,576
2,439,794	4,051,822	78,998	1,781,855	23,637	3,423,149	131,990	1,641,402	197,775	302,715	82,997
178,910	142,028	18,289	116,980	16,317	58,964	16,224	20,182	8,333	12,055	5,474
248,904	134,195	20,048	136,873	10,378	80,193	40,077	13,260	13,978	4,090	9,357
610,976	1,584,451	83,118	507,192	31,218	488,837	58,012	128,410	48,006	4,180	6,625
2,950	370,669	23,038	210,467	12,722	76,972	11,407	34,917	12,091	29,580	1,079
78,407	315,436	11,405	146,490	9,315	50,710	17,766	45,120	14,413	2,320	2,662
158,557	115,620	74,372	134,968	4,843	31,296	3,688	9,167	1,186	1,160	171
9,330	3,077	124	1,185	75	.....	.....	335	.....	.....	.....
27,932	30,845	17,759	21,257	418	4,103	582	7,713	1,143	1,180	139
50	991	20	.....	.....	.....	.....	.....	.....	.....	.....
... .	99	.....	125	.....	.....	.....	.....	.....	.....	.....
200	205	.....	2	.....	.....	.....	.....	.....	.....	.....
437,405	380,941	140,076	269,416	49,073	66,535	27,530	11,259	10,468	2,340	2,367
643	228	.....	.....	3	.....	.....	.....	.....	.....	.....
255	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
.....	.....	.....	.....	5,032	.....	.....	.....	.....	.....	.....
4,253,436	40,120,205	1,597,589	28,443,645	921,057	3,6576,061	1,796,048	32,952,927	2,258,376	11,928,770	2,056,611

The geographical distribution of the sugar maple can best be understood by reference to the table opposite page 257, taken from the U. S. Census Report, and is also shown by the maps on Plate 2,

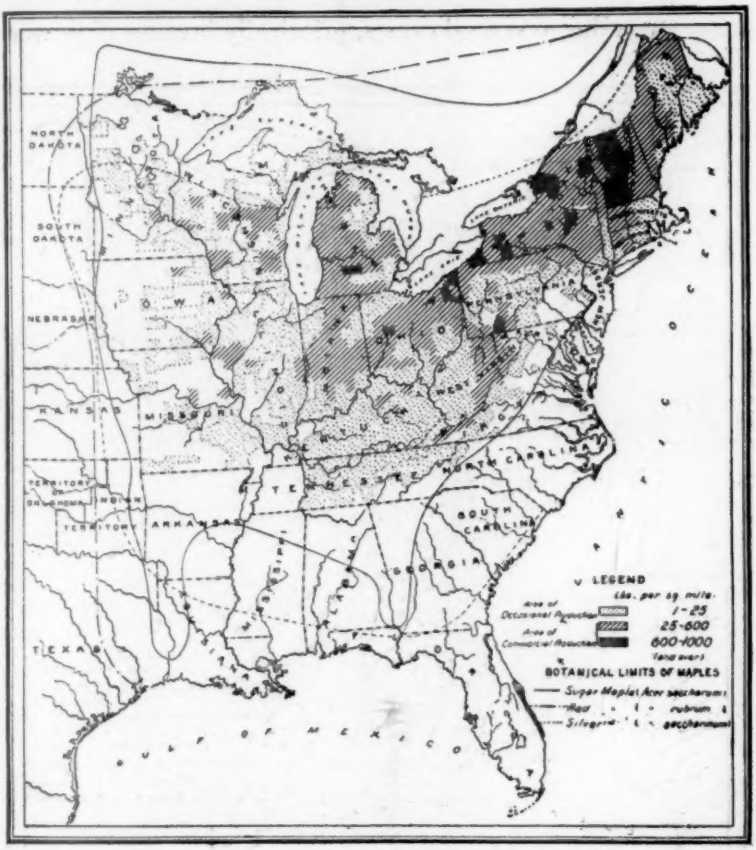


Plate 2. Fig. 1. The field of maple sugar production in 1880.

taken from Bulletin 59, Bur. Forestry, U. S. Department of Agriculture, by permisison.

A better idea of the relative rank of the States producing maple sugar can be obtained from Plate 3, compiled* from census

*Bulletin 59, Bur. Forestry, p. 15.

records for the years 1850 to 1900. About 1860 the maple sugar industry was at its height, the State of New York producing more than any other State, over 10,000,000 pounds of sugar and 131,000 gallons of sirup. The great falling off in 1900 for the entire country was due to several causes, principally because 1899 was a

Plate 2. Fig. 2. The field of maple sugar production in 1900.

very poor season, and in some other States, especially Vermont, the "maple worm" did great damage. In Illinois, Indiana and Michigan the decrease is accounted for by heavy lumbering. This the writer found is also true of western New York; the sugar bushes in the neighborhood of Chaffee and Arcade being

rapidly sold and cut down for making shoe lasts. The maple furnishes a splendid hard wood which is used for many purposes; it is excellent for furniture making, is one of the best woods for making hardwood floors, and is used for almost anything requir-

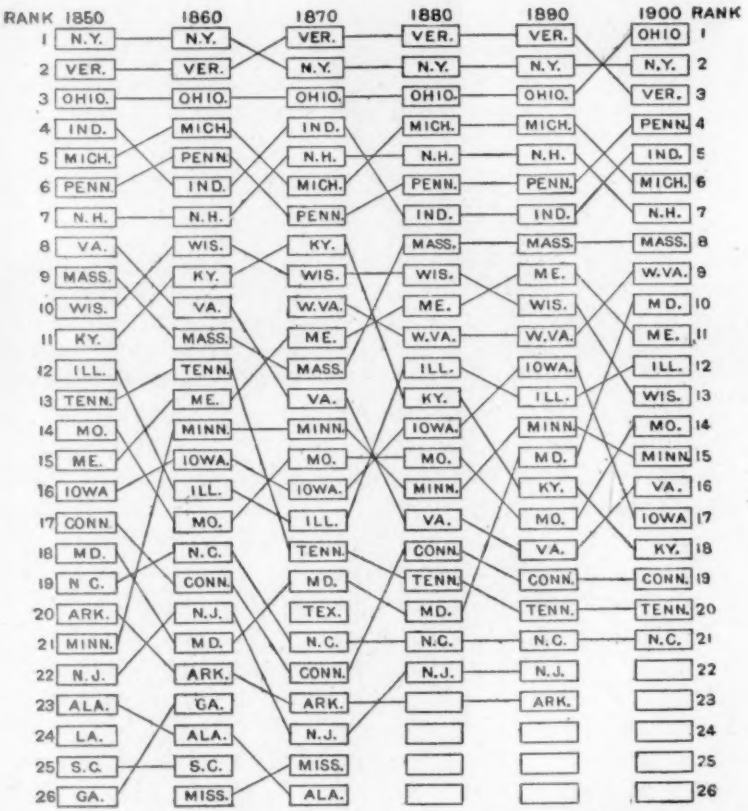

RANK 1850 1860 1870 1880 1890 1900 RANK
1 N.Y. N.Y. VER. VER. VER. OHIO 1
2 VER. VER. N.Y. N.Y. N.Y. N.Y. 2
3 OHIO. OHIO. OHIO. OHIO. OHIO. VER. 3
4 IND. MICH. IND. MICH. MICH. PENN. 4
5 MICH. PENN. N.H. N.H. N.H. IND. 5
6 PENN. IND. MICH. PENN. PENN. MICH. 6
7 N.H. N.H. PENN. IND. IND. N.H. 7
8 VA. WIS. KY. MASS. MASS. MASS. 8
9 MASS. KY. WIS. WIS. ME. W.VA. 9
10 WIS. VA. W.VA. ME. WIS. MD. 10
11 KY. MASS. ME. W.VA. W.VA. ME. 11
12 ILL. TENN. MASS. ILL. IOWA. ILL. 12
13 TENN. ME. VA. KY. ILL. WIS. 13
14 MO. MINN. MINN. IOWA. MINN. MO. 14
15 ME. IOWA. MO. MO. MD. MINN. 15
16 IOWA ILL. IOWA. MINN. KY. VA. 16
17 CONN. MO. ILL. VA. MO. IOWA 17
18 MD. N.C. TENN. CONN. VA. KY. 18
19 N.C. CONN. MD. TENN. CONN. CONN. 19
20 ARK. N.J. TEX. MD. TENN. TENN. 20
21 MINN. MD. N.C. N.C. N.C. N.C. 21
22 N.J. ARK. CONN. N.J. N.J. 22
23 ALA. GA. ARK. ARK. 23
24 LA. ALA. N.J. 24
25 S.C. S.C. MISS. 25
26 GA. MISS. ALA. 26

Plate 3. Showing rank of states producing maple sugar from 1850 to 1900.

ing a hard wood, such as shoe lasts, shoe pegs, tooth picks, chopping bowls, saddle trees, turnery, ship keels and shoes, etc. The sugar maple sometimes grows full of small knotty spots, and lumber made from it has an unusually pretty appearance, and is used in furniture making for making "birds-eye" furniture. Ac-

cording to reports from the Bureau of Forestry, in 1906 nearly one billion board feet of maple lumber were produced. Western New York farmers claim that it is much more profitable for them to sell lumber than to make sugar. This is probably true, considering only a few years' production, but does not apply for the entire life of a maple bush.

PHYSIOLOGY OF THE MAPLE.

The sap in plants corresponds to the blood in animals; it distributes in the plants the food materials necessary for growth. The assimilative processes in plants generally are well understood and need but little brief mention here. The principal food of plants is carbon dioxide which, under the influence of sun-light, the green tissues of the plant decompose, oxygen being given off. The chief result of this decomposition of CO_2 is the formation of a carbohydrate in the plant cells which contain chlorophyll. The first visible product of assimilation is starch,* $(C_6H_{10}O_5)n$; it is of course understood that there are intermediate products, that is, between the CO_2 and the starch. This starch becomes in reality, the food of the plant. It is decomposed and energy set free. This energy is manifested as energy of motion; Goodale† believes that movements of liquids in the plant are due to this energy.

During the season of growth there is produced and stored in the maple tree starch; this is converted into cane sugar, $C_{12}H_{22}O_{11}$, and the latter into invert sugar (dextrose and levulose), which botanists erroneously call "glucose." It is to be noticed that cane sugar or sucrose is not used by the growing leaves or buds, but that it must first be changed into a simple sugar. The starch, a polyose, is changed to sucrose (cane sugar) a diose, and this in turn into invert sugar, which is a mixture of two simple sugars or monoses. This process of inversion begins early in the spring of the year when the tree starts

*First shown in 1862 by Sachs, "Botanische Zeitung," 1862.

†Goodale: Physiological Botany, p. 322.

to grow. The amount of sucrose circulating in the tree will depend principally upon the amount of starch stored during the preceding summer* or season of growth, and this amount of starch in turn depends upon conditions of sun-light and leaf development. Exhaustive experiments made at the Vermont Experiment Station show† that sugar content varied with the amount of leaf surface. Careful measurements and calculations showed that a certain tree in 1899 had a leaf surface of about 9000 square feet; in 1900 this same tree had about 15,000 square feet; this increase was not due to increase in size of the tree, but to the fact that in 1899 the tree was beginning to recover from the effects of an attack of caterpillars, while in 1900 it had almost completely recovered. During these same years, the experimental orchard, the trees of which were in a similar condition, produced sap which in 1899 had an average sugar content of 3.13%, while in 1900 it rose to 3.41%. Isolated trees exposed to a maximum amount of sun-light yield sap which usually contains from 1.5% to 2.0% more sugar. While the carbohydrates stored in the maple consist principally of starch, yet there are undoubtedly others present, either originally formed at the same time when the starch is formed, or the decomposition products of the starch. Stover‡ does not believe that there is enough starch formed and stored in the maple tree to account for all the sugar and the physiological work exhibited in the spring; he believes that mannan also is produced and stored as reserve food. His experiments proved that mannan is present in the sugar maple. Since mannan will readily hydrolyze to mannose, he thought that the latter might be found in the sirup and sugar made from the maple sap. Careful tests however showed no trace of mannose.

It has been shown by microchemical tests that as the starch disappears from the tissues of the sap wood, the content of succrose and invert sugar (called glucose by botanists) increases. A maple branch cut in midwinter and kept for some time in a warm

*The Indians knew what kind of a sugar season to expect; they said that if the maple leaves ripen and turn yellow, and the buds perfect themselves so that the leaves fall off naturally without a frost, then there will be a good flow of sap the following season; if the leaves fall prematurely and the buds are not perfected, then there will be a poor yield of sap.

†Vermont Station, Bul. 103, p. 55.

‡F. N. Stover: Bul. Bussey Inst., 1902, p. 34.

room soon changes its starch to sucrose and invert sugar. It is now generally believed that these changes are due to the activities of the protoplasm and brought about by chemical ferments or enzymes secreted by the living cell.

The change from sucrose to invert sugar must take place principally in or near the leaves and buds, since but a very small percentage of invert sugar is found in the sap; at least this is the case at the beginning of the season. As will be seen from the results of analyses of a number of maple products by the writer, there is always present some reducing sugar (invert sugar). It is known, of course, that some of the sucrose becomes invert sugar on account of being heated during the evaporation of the sap, or by fermentation and microorganisms before and after evaporation. Early investigators did not find invert sugar in maple sap, and all invert sugar was supposed to be formed during evaporation. Results obtained by the writer as to reducing sugar in different sirups and sugars indicate that a difference in the process of preparation could not account for the wide ranges, and that there must be corresponding differences in the original sap. Other investigators have noticed this, and it is now generally known that sirup made from first runs of sap (early in the season) is low in reducing sugar, while that made from late runs produces a dark product with larger amounts of invert sugar. Analyses of fresh saps, early in the season, made by the writer, are as follows:

	Reducing sugars.	Total sugars.
Acer saccharum	0.029%	3.46%
Acer saccharinum	0.020%	3.20%

These results show that reducing sugars do occur in the sap, and sirup and sugar made from such sap would contain about 0.50% reducing sugars even if none are formed during or after evaporation of the sap.

It might be supposed that invert sugar in maple sap is formed from sucrose by the malic acid also present, but if this were the case, then, since all genuine maple products contain malic acid we would expect considerable, and about the same amount, in the different sirups or sugars. Fruit acids cause but very little hydrolysis of cane sugar. Invert sugar occurs in some ripe fruits, but Buignet has shown that it is formed by the action of a ferment and not by a fruit acid.

Maple sap is essentially a dilute solution of sucrose, and contains traces of reducing sugars (invert sugar), organic acids, chiefly malic, mineral matter (inorganic salts) and small amounts of protein substances. As might be expected, the composition of the sap varies greatly; it may be different for different trees and also vary for the same tree at different times during the season and with conditions of weather and sun-light. An average of a great many analyses of sap shows the sucrose content to be about 3%. Many trees yield sap containing less than 3% of sucrose, and some trees give a much higher sucrose figure. Wiley* reports a tree producing a sap containing 9.88% and another containing 10.20% of sucrose; but in nearly all cases where the percentage of sucrose is higher, the quantity of sap is small. The average sucrose for the season for the tree last mentioned was 5.01%.

The average yield of sugar per tree for a season is about three pounds; many trees do not produce this amount, and others greatly exceed this. Jones† reports measurements and calculations of a certain small maple tree showing that it contained about 120 gallons of sap at the opening and 150 gallons at the close of the sugar season. A tree containing 150 gallons of sap would carry about thirty-seven pounds of sugar, taking 3% as the sugar content of the sap. Such a tree if it yields three pounds of sugar, would give up only about 8% of its total sugar. Larger trees, producing about three pounds of sugar, would yield probably not more than 4% of its total sugar. With 3% sugar, it would require about seventeen quarts or thirty-four pounds of sap to produce one pound of sugar; the pails usually used for collecting sap will hold a little over four gallons, and the farmer expects a pound of sugar from a pail full of sap. A fair average daily flow of sap is about five quarts or ten pounds, and about twelve gallons for the season. Jones reports‡ a tree which produced 11.95 pounds of sugar in one season; Dr. Rush§ in his remarkably complete description of the maple sugar industry in 1792 mentions that a Mr. Low, of Montgomery County, New

*Bul. 5, p. 209, Chem. Div. U. S. Dept. Agr.
†Vermont Station, Bul. 103, p. 139
‡Vermont Station, Bul. 103, p. 134
§Trans. Am. Philos. Soc., 1792.

York, made twenty pounds and one ounce of sugar from one tree, the sap running from April 15 to 23, 1789; this tree yielded twenty-three gallons of sap on the first day.

The quantity* of invert sugar in maple sap is usually recorded as "a trace;" Morse† reports a tree yielding a sap with an average of .0075%, and another tree with .0123% of invert sugar. In the sap used in the laboratory for making pure sirups, the writer found the following percentages of reducing sugars: hard maple sap, 0.029%, soft maple sap, 0.020%.‡

Of the organic acids in maple sap, only the malic acid has received attention. This exists both free and combined; Wiley§ made determinations of the free acid by titrating the fresh sap with n/100 soda; the maximum amount of acidity, calculated to malic acid, was 0.005%, and was as low as 0.0005%. That this does not represent all the malic acid present is shown by the fact that a genuine sirup, containing 66% of sucrose, shows about 0.5% of total malic acid, while if the original sap contained only 0.005%, the sirup made from it would contain only 0.11% malic acid. A 65% sucrose and 0.5% malic acid content in a sirup is produced from a sap containing about 0.023% total malic acid.

The principal inorganic elements in maple sap are potassium, calcium, sodium, magnesium and iron in the order named. It appears impossible to determine the combinations in which these elements exist in the sap; change of combinations would occur during evaporation, and on ignition of sirup or sugar for ash determination, the organic acid radicals would change to carbonate. For the composition of ash obtained from maple sap, Wiley¶ gives the following data, calculated to percentage on original sap:

K_2O	CaO	MgO	Na_2O	Fe_2O_3	P_2O_5
.0314%	.0207%	.0061%	.0013%	.00066%	.00596%

These figures represent an average of four analyses of sap from the same tree on different days, the tree being tapped about three feet from the ground. Further information is given under "ash," where in addition to these data, the quantities of manganese,

*Wiley: Bul. 5, Chem. Div. U. S. Dept. Agr., p. 193.

†N. H. Station Bulletin.

‡The amount of reducing sugars and solids not sugar increases toward the end of the sap season. See Ver. Bul. 26, p. 40.

§Bul. 5, p. 210, Chem. Div. U. S. Dept. Agr.

¶Bul. 5, p. 193, Chem. Div. U. S. Dept. Agr.

CO_2 So_3 and Cl are reported. The total ash obtained from sap is relatively considerably greater than found in sirup or sugar, because ash is lost during evaporation by skimming, clarifying and straining, and settling out of calcium malate.

Maple sap contains small quantities of protein substances. Wiley* reports an average of .019% in the sap of four trees. The average from a grove of 700 trees was .0088%, and from another of 1500 trees it was .0103%.†

In this connection there should be mentioned what is known among the farmers as "niter" or "sugar sand." This is a sand-like, gritty substance which is deposited during the process of evaporation of the sap; this deposition does not begin until the sap has been concentrated to a thin syrup of about eight pounds per gallon. This "niter" is removed from all good maple products by either allowing the sirup to settle or straining it through felt or other material; this should be done also if the sirup is to be concentrated for making sugar, otherwise the sugar will be gritty. "Niter" is found in all pure maple products, varying, however, from small amounts to large quantities, depending upon method of preparation and character of the soil upon which the maple trees grow; it has been stated that trees on lime soil produce more "niter" than others.

But few analyses if "niter" are reported; the following is taken from the Indiana Station Report for 1899:

Water	6.11%
Insoluble matter	9.13%
Reducing sugars	12.74%
Sucrose	26.88%
Calcium	12.89%
Malic acid	20.86%
Potassium	0.72%
Protein	0.40%
Magnesium	trace

This evidently is an analysis of "niter" which still contains considerable sugar or sirup; part of the sucrose is probably present as

*Ibid. p. 210.

†During evaporation of sap the protein substances are partly coagulated and skimmed off. For amounts left in the finished products see Hortvet, Report Minn. State Dairy and Food Commissioner, p. 455 (10th An. Report).

calcium sucrate. It is usually stated that "niter" is mainly calcium malate; it has been stated* that "niter" is principally calcium tartrate; some still believe that it is a mixture of calcium malate and calcium tartrate.

The question as to the cause of pressure and flow of sap in plants has been the subject of many researches, especially by botanists; but in spite of this, there still exists a great difference of opinions as to the explanation of these phenomena. It will not be necessary to discuss this subject, except with reference to the maple. Perhaps the best summary of theories as to the cause of sap flow is that given by L. R. Jones:†

(1) High water content of the tree. This does not explain the flow of sap, since the tree contains more water several weeks after flow ceases than it does during flow.

(2) Root pressure. Exhaustive experiments made by the workers at the Vermont Experiment Station‡ show that there is very rarely any root pressure.

(3) Alternate freezing and thawing. This was a popular theory twenty-five years ago, but does not hold good, since the wood of the maple tree seldom freezes.§

(4) Physical expansion due to rise and fall of temperature. If this theory were correct, the rate of sap flow should be proportional to rise in temperature, which is not the case in practice. In the experiments made at the Vermont Station there was observed in a maple tree trunk a change in pressure from five pounds suction per square inch to a pressure of twenty-five pounds within a few hours; it does not seem likely that this phenomenon can be explained by expansion of gas or other substances in the maple trunk.

(5) Jones believes¶ that the flow of sap in the maple is due to activity of living cells under certain stimuli or conditions. The principal stimulus is undoubtedly the more or less sudden fluctuation of temperature from slightly below 0° to slightly above 0°. This is in accord with the fact that during the sap season the sap

*Vermont Station Report, 1872, p. 222.

†Paper read before Vermont Sugar Makers' Association, kindly loaned to the writer before publication.

‡See Bul. 103, Ver. Ex. Sta.

§See Bul. 103, Ver. Ex. Sta.

¶See also "Experiment Station Record" 17, p. 123.

flows best on bright days preceded by nights during which there was freezing.

The rate at which the sap flows in a maple has been determined by Jones and Orton,* who found that the rate when the sap is flowing in the direction of the grain of the wood toward the tap hole or orifice, is from two to six inches per minute. C. H. Jones, *et al.*, have made the maple sap flow the subject of exhaustive study,† and almost all phases of this subject were fully studied and reported. By inserting pressure gauges into different parts of a tree and making observations of temperature, etc., many interesting results were obtained. By using self-recording gauges and thermometers continuous records were obtained. Two of these are shown in Plates 4 and 5.‡ Plate 4 shows that during that experiment the temperature changed frequently from above to below 0° (32°F.) and that there were, parallel with these changes, fluctuations in pressure; when the temperature remained stationary, the pressure was also stationary *near 0°;* suction results when the temperature falls below 0° (32°F.). Plate 5 shows temperature changes nearly all above 0°; under these circumstances, even though the temperature variations are considerable, the pressure changes are but very slight, and always near 0°. In two instances, the plate shows, the temperature went below 0° and immediately the pressure changes became much greater. The plate also shows that "outer pressure" (depth two inches) and "inner pressure" (five inches) do not differ materially, and that temperature alone is not responsible for these changes.

MANUFACTURE OF MAPLE PRODUCTS.

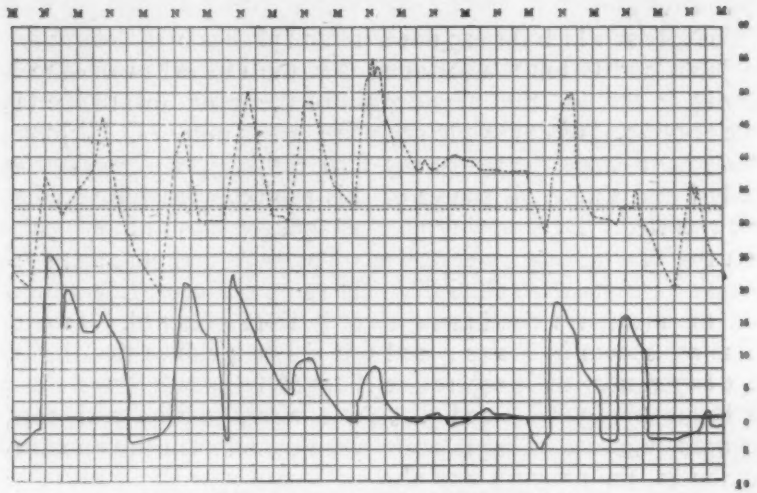
It is not intended to give a detailed technical description of maple sirup and sugar making. However, since the most important part of this paper is to deal with the analysis of maple products, a short description of the process of manufacture seems necessary for a better undesrtanding of the analytical data

As stated before, maple sap may be considered a dilute (3%) solution of sucrose (cane sugar) with small amounts of other or-

*Bul. 103 Ver. Ex. Sta., p. 106.

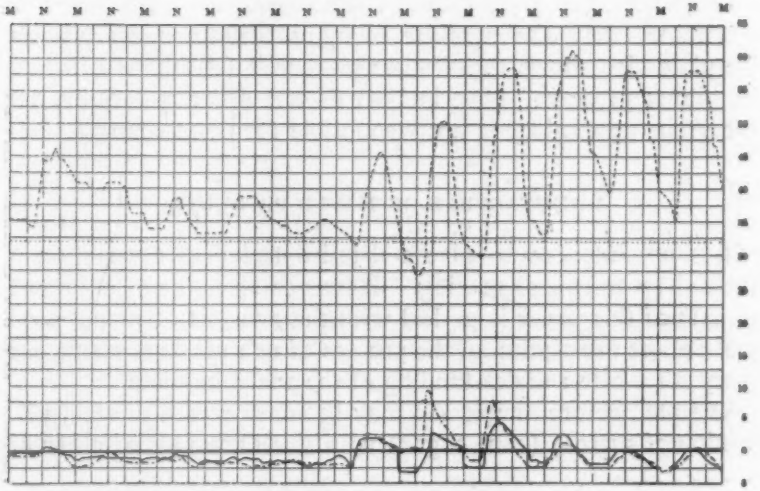
†Bul. 103, "The Maple Sap Flow," Ver. Ex. Sta.

‡By permission from Bul. 103, Ver. Ex. Sta.



M midnight; N noon; —. pressure in pounds; - . - . -, temperature in ° F.

Plate 4. Showing relation between temperature and sap pressure.



M midnight; N noon; — inner - . - . outer pressure in pounds; - - - temperature in °F.

Plate 5. Showing relation between temperature and sap pressure.

ganic and inorganic substances. That the sap contains sugar must have been known long before any sirup or sugar was made from it. It would naturally suggest itself that the sugar might be obtained by evaporating the water from it. Two natural processes acocmplish this; first, freezing, and second, spontaneous evaporation. Both were known to the North American Indians, also to our early settlers. One of the earliest artificial processes of evaporation was that of Indians who heated stones red hot and placed them into vessels containing sap. This of course was necessary as long as they had no metallic vessels; these vessels were one of the first things they obtained by trade from early settlers, and they soon used them for evaporating sap for making sirup and sugar. An interesting illustration is shown in Plate 1, the original of which is in "Lafitau, Moeurs des Sauvages Ameriquains," Vol. II, p. 154 (about 1700), and shows the manufacture of maple products in all its stages, as Lafitau saw it among the Indians.

The primitive kettle process is still in use to-day, due to the fact that maple products are made by a great many small producers, much in the same manner as cane sirup for home consumption in Central Illinois and other places. Plate 6* shows this method as practiced in Canada to-day. Plate 7† shows a different arrangement of the kettles, permitting their removal from the fire for taking out the sirup. Plate 9 (writer's photograph) shows evaporators used in Pennsylvania. Although pans are used, the process is essentially the primitive kettle process, in which sap is boiled sometimes all day, fresh sap being added continually, the sirup being removed at night. This long boiling produces a very dark product, containing more reducing sugars and impurities than the product from modern evaporators. This dark colored product is still preferred by some, since it has a very strong flavor.

The larger producers of maple products use more modern apparatus, called evaporators. With this form of apparatus the process is continuous, the sap flowing in at one end while the sirup is drawn off at the other. This of course produces a much lighter colored product than long boiling. A form of direct heating

*From Buffalo "Courier."
†Vermont Station Report.

Plate 6. Open kettle evaporation as practiced in Canada.

Plate 7. Open kettle evaporation. Kettles can be swung from fire.

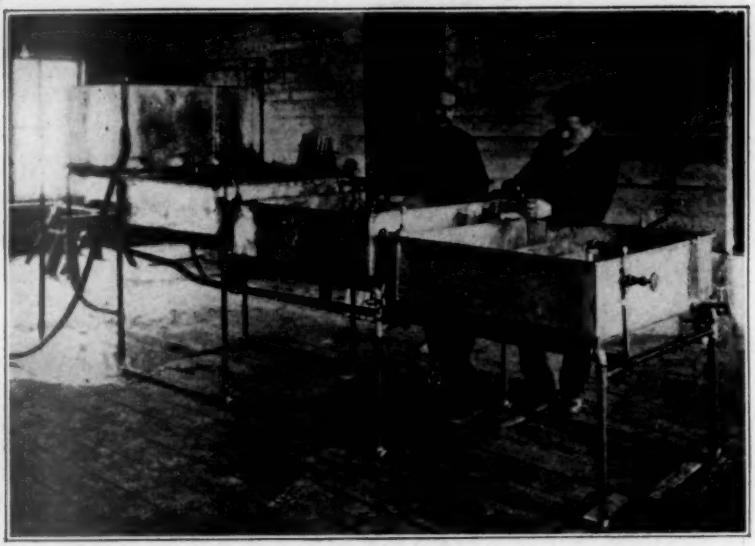


Plate 8. A modern steam-heated evaporator.

Plate 9. Open air, flat kettle, direct fire evaporator in Pennsylvania.

Plate 10. New York maple sugar camp. (Author's photo.)

Plate 11. Typical Vermont maple camp. (From Vermont Station Report.)

evaporator is shown in Plate 12*, and Plate 8† shows a steam heated evaporator. Before evaporating, the sap is strained; it should be collected and evaporated at least daily, since it readily ferments or "sours," unless the most scrupulous cleanliness is observed. The writer has been unable to find any statements as the kind of fermentation and nature of products formed. Sap collected by the writer when allowed to "spoil" acquired a strong

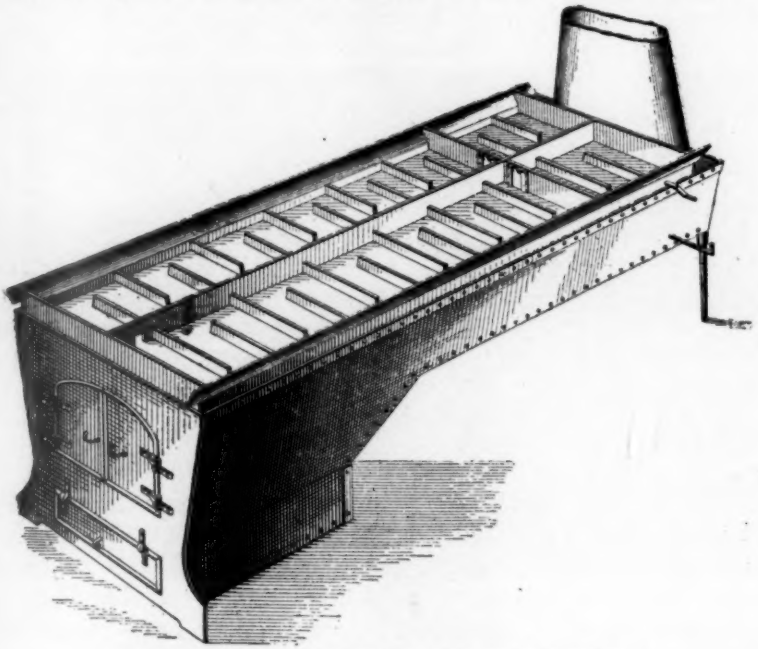


Plate 12. Modern, direct heating, continuous process evaporator.

odor of lactic acid, and the term "souring" seems quite appropriate.

For making sirup, the sap is boiled until it has a specific gravity of 1.325; at this density it boils at 219°F. and the sirup weighs eleven pounds to the gallon. This is the standard for sirup; if boiling is stopped before this point is reached, the sirup will be thin and more liable to ferment; if the density is greater than 1.325 sugar will separate (crystallize) from the sirup. Modern

*From Bul 59, Bur. of Forestry.

†Vermont Station Bulletin.

evaporators use a hydrometer or thermometer and produce a uniform product. Others guess at it, or take out a little from time to time and allow it to cool.

The various sap conditions have already been mentioned. During the evaporation, the proteids are coagulated, rise to the top and are partly removed, together with other substances, by "skimming." As the sap becomes more concentrated, the "niter" becomes more insoluble and is deposited.

If sirup only is to be made, evaporation is stopped at 1.325 sp. gr., the sirup allowed to cool, strained (to remove "niter," etc.), and put in cans. To make sugar, the evaporation may be continued until it boils at 233°F.; in case the "niter" is not removed, the temperature must be up to 235°F.; the sirup is then placed into moulds where it solidifies on cooling. This produces an inferior sugar, since it contains the "niter," and a better and more usual plan is to make sirup and draw off, allow to cool and settle, strain and continue the concentration. By the small producer this process, called "sugaring off," is usually done at home* (See Plate 13) while the preliminary evaporation is done in the "sugar bush."*

STATISTICS

While maple sirup and sugar are well known all over the United States, yet the importance and magnitude of the industry are hardly ever mentioned or understood, except in the New England and Lake States and adjoining Canada. In the State of Vermont it is a very important industry, and the name "Vermont" and maple products are closely associated, frequently, as will be seen later, illegally. The distribution and density of maple sugar production for the year 1880 and 1900 in shown in Plate 2.† The table on page 259 shows the sirup and sugar production of the different States since 1850, and the relative rank of each State is shown in Plate 3‡ By act of Congress of October 1, 1890, there was provided a bounty on sugars made in the United States. The

*Detailed descriptions of the modern methods for sirup and sugar manufacture can be found in Bul. 59, Bureau of Forestry, and the Reports and Bulletins of the Vermont Agr. Ex. Station.

†From Bul. 59, Bureau of Forestry

‡From Bul. 59, Bureau of Forestry, p. 15.

act provided that after July 1st, 1891, and until July 1st, 1895, a bounty be paid on sugars made either from beet, sorghum, cane or maple, two cents per pound on sugars testing 90% or over by the polariscope, and $1\frac{3}{4}$ cents per pound on sugars testing less than 90% but more than 80%. The effect of this bounty was not as expected, more farmers preferring to make sirup instead of sugar, and others did not take advantage of it on account of the formalities and requirements involved.

Plate 13. Straining and "sugaring off" at home.

ANALYSIS OF MAPLE PRODUCTS.

Until now, maple products have always been found in the markets grossly adulterated. Not many years ago, it was almost impossible to get a pure sirup or sugar. The reasons for this extensive adulteration were the high price of maple products and the inability of the chemists to detect adulteration. This will be more fully discussed later under "adulteration." Even to-day, many chemists are unable to differentiate between pure and adulterated products. Important contributions to the literature on analysis of maple products have been made by Jones* and

*17th Annual Report, Vt. Ag. Ex. Sta., p. 446; also 18th Annual Report, Vt. Ag. Ex. Sta., p. 315.

Hortvet;* a great deal of analytical work is also reported by the chemists of the Canadian Inland Revenue Department. Considerable analytical and research work (as yet unpublished) has been done by Prof. H. M. Hill, University of Buffalo. Some of his work will be mentioned later, by permission.

In the following there are given all the important determinations made in the analysis of maple products.

COLOR.

Maple sugar is not refined like granulated sugar; it corresponds to that kind of crude cane sugar called "concrete." Since maple sugar is identical with sucrose, it follows that on refining it, it would lose its color and become white. The writer has a sample of maple sugar made in the laboratory by evaporating sap very slowly in a porcelain vessel; on recrystallizing this it became almost as white as granulated sugar. Maple products vary in color from a very light brown to almost brownish black.† This variation is due to two causes, principally: first, stage of the sap season, *i. e.*, whether at beginning or end of season; second, method of manufacture. Near the end of the sap season, especially if the buds have started, the sirup and sugar are quite dark in color; this is due to the fact that at this time the sap contains increasing amounts of reducing sugars and solids not sugar, and these caramelize or burn much easier than cane sugar. It is also believed that the character of the soil influences the color of the maple products.

The method of evaporating the sap has considerable influence on color. The old kettle method where some of the sap was boiled all day resulted in a very dark colored product, due principally to the formation of caramel. To determine if the presence of "niter" accelerates the formation of caramel (from invert sugar which the "niter" might produce from sucrose) the writer made duplicate dilute solutions of cane sugar and evaporated them in glass, adding a little "niter" to one sample. After several days boiling, the syrups were still almost equally colorless.

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*Jour. Am. Ch. Soc., 26, p. 1523.

†The color of the maple product, therefore, has no relation to purity of the product.

Commercial maple products are always manufactured in metallic vessels; experimental samples made by the writer, using glass or porcelain, always resulted in light colored products. Metal transmits the heat much more readily and is therefore more apt to "scorch" the product.

Maple products usually show a reaction for tannin when tested with $Fe Cl_3$. Some of this tannin undoubtedly reacts with traces of iron from the vessels used and this darkens the product. According to Faradiss* caramel contains humic acid, formic acid, and other bodies; these acids would attack iron, and the resulting salts would readily react with tannin.

The color or appearance of a maple product may also be influenced by small sugar crystals (in sirup, when evaporated too far), malates or "niter," and carbonates, in suspension; phosphates, organisms and fermentation. To determine what proportion of color is due to caramel, the writer tested a number of samples with amyl alcohol. This does not discolor caramel, and if the color is due to caramel, the layer of amyl alcohol should remain colorless. Upon testing a large number of samples in this manner it was found that all pure products contain enough coloring matter other than caramel to give a distinct color to amyl alcohol. This fact was made use of in the *"color test,"* to be described later.

COLOR AND AROMA.

It is these that give to maple products their value. The flavor cannot be described but must be learned by experience; it is very pleasant and is characteristic. Experts who have tested a great many products can often detect adulterations without a chemical analysis. While the maple flavor is not equally strong in products from various parts of the country, yet dilution with cane sugar, sugar-house sirup, glucose, etc., always reduces the strength of the flavor, and often also imparts a special flavor to it, according to the adulterant used. The writer has examined a great many samples from each of the principal maple districts and has noticed a great difference in flavor. Maple sirup and sugar produced in Pennsylvania and Ohio often have but little maple

*Zeit. f. Untersuchung Nahr. Genussmittel, Vol. 2, p. 881.

flavor; one might say they taste "flat;" usually, the less maple flavor, the more a product will taste like ordinary cane sugar sirup or sugar. Products coming from Vermont and New York have a much stronger maple flavor; it is, however, not too strong and might be described as "delicate;" these products are preferred over all others by most consumers. The strongest flavor is found in the Canadian products;* all the darkest samples analyzed by the writer came from Canada.† People used to Ohio products do not care for the strong flavor found in the Canadian products; the latter remind one of the old-fashioned open-kettle-method product; the flavor is very strong in this maple, sometimes has what one writer calls a "woody" character. It appears from what has just been said that climate has an influence on flavor; the colder the more maple flavor develops. This may be due to the fact that in colder climates the buds do not start as soon as in warmer ones.

Imitation maple products, those containing very little or no real maple, always have a flavor which can most always be distinguished from the pure product. The writer has found fenugrek, vanilla, prune juice, resinless guaiacum (tr) in samples of sirup. A pure maple sirup sometimes develops a most disagreeable odor and flavor, resembling such as are produced by putrefaction of the proteins. Out of about sixty sirups the writer found three with such odor and flavor, and in these cases were caused no doubt by decomposing egg albumen or milk or cream, these being used in the manufacture to clear the product and also to prevent boiling over.

In a few instances the writer has also noticed an odor resembling hot glue; this was especially noticable in a sirup made by the writer from the sap of soft maple (A. saccharinum). This odor is probably due to the nitrogenous matter present; such a sample after it has begun to ferment, develops an exceedingly objectionable odor and taste.

A test for the odor of products under examination is as follows:‡

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*It is well known that the strong flavor and color of the Canadian products are much used by mixers; by adding a little of this to cane sugar sirup one obtains a very good imitation maple sirup.

†One sample now on hand nearly black.

‡Jones: 18th An. Rept. Ver. Station, p. 335.

About 20 g. of sirup or sugar are weighed into a 4 oz. beaker, dissolve in from 20 to 40 c.c. of hot water, place on asbestos board and boil; the amount of water added is such as to cause the sirup to boil at 215°F. Boil gently for a few minutes, stir gently, and note odor. In making this test the writer has found it necessary always to remove the beaker from the flame and asbestos, as these interfere seriously with the sense of smell. The true maple odor is always obtained from pure products under these conditions; the odor is characteristic, and must be learned by experience with pure products.

As far as known to the writer there is no record of research on the aromatic constituents of maple products. It has been stated* that the maple flavoring is probably an ether (ester?) or aldehyde possessing a high boiling point. It is further stated that these flavoring substances are partly volatile at temperatures reached during the evaporation of sap, for there is always the well known aromatic odor in the vicinity of a sugar camp in operation. However, the really volatile part is probably exceedingly small, and the writer believes that the odor so prominent during sap evaporation is due mostly to fine particles of sap or sirup thrown into the air during the boiling or carried with the steam, much in the same manner as salt is found in sea air, or caustic soda in the air over a vessel in which a solution of the caustic has just been made.

The following experiment was made by the writer in an attempt to isolate, if posisble, the flavoring matter. Pure, fresh maple sap was boiled in a large glass flask (A) connected by a glass condenser with another flask (B); this second flask had a reflux condenser (C), the latter being connected at the top with another vertical condenser, the bottom of which reached into a small flask (E) containing water. (See Plate 14.) Six liters of fresh maple sap were placed in A, the apparatus connected and the sap boiled until it had about the consistency of sirup; the distillate in B had the characteristic maple odor, except that it was not as pleasant and not nearly as strong as maple sirup; the odor resembled that of corn cobs, or, as described by an asisstant, that of pop-corn. It suggested to the writer the odor noticed when a strong solution of glycerin is boiled; on boiling some of the lat-

*Wiley, Bul. 59, Bureau of Forestry, p. 47.

ter and comparing odors it was found that they seem to be identical. The flavor of the contents of flask B was not sufficiently marked to be compared with anything. This shows that but very little of the flavoring substances in maple sap is volatile. Nothing came over into flask E and the water in the flask acquired no odor or flavor of any kind. This again shows that the flavoring substances are not very volatile, or are at least easily condensed and held in water (in B). In order to isolate, if possible, the

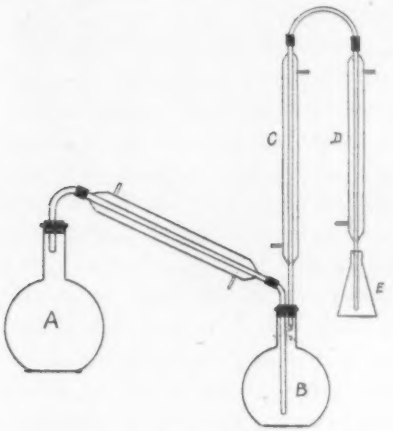


Plate 14

flavoring substance in B, the contents were transferred to a separatory funnel and extracted with ether and the latter allowed to evaporate spontaneously; from about 5500 c.c. of distillate there was obtained only a trace of residue after evaporation of the ether; this residue had the same odor as described before. It appears from this that if the flavoring substances are ether or aldehydes, they are present in but very small amounts or are but very little volatile. The writer hopes to continue experiments on this line next year, using a considerably larger amount of sap, also using different methods of separating the flavoring substances both from the distillate and the remaining sirup.

(*To be continued*)

Section of Physics and Chemistry.

Quantitative Separation of Tin from Manganese, Iron and Chromium by Electrolysis.

By M. N. Puschin.

(From "Journal de la Société Physico-Chemique Russe," XXXVIII, 764.)
Translated from "Moniteur Scientifique," XXII, I. 262, April, 1908, by W. J. Williams, F. I. C.

There has been given in one of the preceding memoirs* a process for the quantitative separation of tin from nickel and cobalt, based on the property of these latter of not separating from solutions acidified with oxalic acid.

A priori it seems probable that iron, as the third metal of the iron group, as well as manganese and chromium, very close in the system to the three preceding metals, would not separate from solutions acidified with oxalic acid, and would thus permit their quantitative isolation from tin.

These suppositions were completely realized as far as regards iron and manganese, and partially in regard to iron granting the property of the latter of forming oxalates of the protoxides as well as of the oxides.

SEPARATION OF TIN FROM COMBINATIONS OF THE PROTOXIDES OF IRON AND OF MANGANESE.

The oxalates of the protoxides of iron and of manganese are completely analogous to those of nickel and cobalt; they are difficultly soluble in solutions acidified with oxalic acid; they give precipitates of a bright yellow color for iron and whitish for manganese, if the solution is heated nearly to boiling. Like

*Journal de la Société Physico-Chemique Russe, XXXVII, 828.

nickel and cobalt, neither the iron nor the manganese will be separated by the current from a solution in equilibrium with these precipitates. This is shown by the following experiment: To 25 c.c. of a solution of iron sulphate or manganese sulphate, containing about 0.5 gram of iron or of manganese, are added 25 c.c. of an acid solution of ammonium oxalate (saturated at room temperature) and 100 c.c. of a similarly saturated solution of oxalic acid; on heating the liquid nearly to boiling, it gave a precipitate of oxalate of protoxide of iron or of manganese. After the solution has been allowed to stand a while, the liquid is submitted to electrolysis, at the room temperature. Here are the results tabulated:

TABLE I.

Experiment.	Weight of the Cathode before experiment.	Tension of the Electrodes.	Density of the Current per square decimeter.	Duration of the Experiment.	Weight of Cathode after experiment.
With manganese—					
	13.1764	3.2 volts	2.5 amperes	2 hrs. 35 min.	13.1764
	13.1764	4.2 "	4.0 "	1 " 25 "	13.1764
With iron—					
	13.4234	3.2 "	4.5 "	2 " 50 "	13.4234
	12.4234(?)	3.5 to 4.2 "	4.0 "	1 " 48 "	13.4234

It follows from the above table, that under the conditions therein indicated, the current will separate neither iron nor manganese from the solution. Since it is easy to separate tin quantitavely from acid solutions of binoxalate by ammonia binoxalate (Klassen's method), it is clear that it is also easy to separate tin quantitatively in this way from manganese and from iron where these exist in the solution as salts of protoxides.

However, it must be observed that in analyses iron is more frequently found in combinations of the oxide than of the protoxide; since the combinations of protoxide easily change to combinations of oxide, without introducing any new metal, such as bromine for example. That is why in studying the method of the electrolytic separation of tin from iron, the combinations (or salts) of iron oxide should be especially considered. The same is true in a certain degree for manganese. But it is much more difficult to separate tin from the salts of iron oxide.

The binoxalates of iron (or of manganese) and of ammonium, differing from the salts of the protoxides, dissolve in a solution of oxalic acid; on the other hand, the salt of ferric oxide, under the influence of the cathode current, easily decomposes into a salt of

the protoxide, which being insoluble in oxalic acid, precipitates in part at the bottom of the cell and in part envelopes the cathode, thus preventing the regular precipitation of the tin. The different attempts made to find a means of solving this difficulty have not hitherto given any satisfactory results; therefore the problem of the separation of tin from iron can be considered as only half solved, especially in respect to iron protoxide.

SEPARATION OF TIN FROM COMPOUNDS OF MANGANESE OXIDE.

The question of the separation of tin from compounds of manganese oxide presents a more favorable aspect. In the presence of a sufficient quantity of oxalic acid, if the tension does not exceed 3 volts, under the experimental conditions indicated above, and the density of the current is not too great, the manganese is not deposited on the cathode, neither as metal nor as an insoluble oxalate of the protoxide, so its complete separation from tin is possible. This follows from the following experiments:

TABLE II.

	Experiments.	Quantity taken for analyses.	Tension at the electrodes.	Density of current per sq. decimeter.	Result.	Per ct
			Volts.	Amperes.		
1	Tin (Sn)	0.4269 gr.	2.2 to 2.6	0.8 to 1.0	Sn 0.4260	98.79
	Manganese (Mn)	0.5 gr.				
2	Tin (Sn)	0.4634 gr.	2.2 to 2.9	0.8 to 1.0	Sn 0.4623	99.76
	Manganese (Mn)	0.5 gr.				
3	Tin (Sn)	0.5253 gr.	2.2 to 2.8	0.8 to 2.0	Sn 0.5244	99.83
	Manganese (Mn)	0.7630 gr.				
4	Tin (Sn)	1.0761 gr.	2.2 to 2.9	1.5 to 3.0	Sn 1.0760	99.99
	Manganese (Mn)	0.5 gr.				

From the above table it is evident that the method given for the electrolytic separation of tin from manganese gives perfectly satisfactory results. It must be particularly noticed that when half way through the electrolysis it is desirable to add 5 to 10 grams of oxalic acid, that the solution may remain sufficiently acid. Then, as has been said above, the tension of the electrodes must not be increased above 3 volts, or, under these conditions, traces of manganese may be deposited. The density of the current should not be too great; for example, it should not exceed 3 to 4 amperes to the square decimeter, for the too rapid disengagement of hydrogen at the cathode can cause (though only to a small extent) the reduction of the salt of manganese oxide to an insoluble salt of protoxide, which is assuredly not to be desired.

SEPARATION OF TIN FROM CHROMIUM.

The separation of these two metals is the easiest and the most complete of all. The chromium is not deposited by the current in a solution acidified with oxalic acid. Experiments prove it.

About 5 grams chromium were dissolved in a mixture of hydrochloric acid and bromine. As in the preceding experiments the solution was neutralized with ammonia, and 25 c.c. of a solution of ammonium oxalate, saturated at room temperature, and 100 c.c. of a similar solution of oxalic acid were added, after which the liquid was electrolyzed:

TABLE III.

Weight of Cathode before experiment.	Tension of electrodes.	Density of Current per square decimeter.	Duration of experiment.	Weight of Cathode after experiment.
13.6609 gm.	2.9 to 4 volts	4.8 to 5.6 amperes	1 hr. 20 min.	13.6609 gm.
13.6609 gm.	5 "	9.2 "	2 " 25 "	13.6606 gm.

These two experiments show clearly that the chromium does not separate from the solution under these conditions. Accordingly about 0.5 gm. tin and approximately as much chromium were dissolved in a mixture of hydrochloric acid and bromine; to the neutralized solution 25 c.c. of a solution of ammonium oxalate, saturated at room temperature, were added and 100 c.c. of a similarly saturated solution of oxalic acid, all the liquid diluted with about 200 or 250 c.c. of water was electrolyzed. The results are given in

TABLE IV.

	Quantities taken for analyses.	Tension of the electrodes.	Density of Current per sq. centimeter.	Result.	Per ct.
1	Tin (Sn).....0.5518 gm. Cromium (Cr)..0.58 gm.	2.5 volts	1.2 amperes	0.5505 gm.	99.77
2	Tin (Sn).....0.5090 gm. Cromium (Cr)..0.5 gm.	4.0 "	5 "	0.5089 gm.	99.98
3	Tin (Sn).....0.5516 gm. Cromium (Cr)..0.53 gm.	3.9 "	5 "	0.5514 gm.	99.96

This table shows clearly a very perfect separation of tin and chromium by the method described, and the results obtained for tin are very satisfactory.

ELECTROLYTIC DETERMINATIONS.

The following is a resumé of the work which forms part of the "Contributions of the John Harrison Laboratory of Chemistry."

They treat of the electrolytic charge and of the electrolytic separation of metals, using a rotary anode. This anode, introduced by Exner, permits of very rapid work.

∴

J. R. Withrow has studied the electrolytic precipitation of gold from gold chloride, in the presence of potassium cyanide and sodium sulphide; he used Ingham's* apparatus, and the precautions laid down by Exner† were followed in the experiments with cyanide.

The first trials confirmed Exner's observations, showing, nevertheless, a smaller minimum of time than he indicated. The deposits, washed without interrupting the current, were of a beautiful yellow color, and formed very adherent microscopic needles.

The following table gives a series of trials undertaken with the object of ascertaining the minimum of time necessary for a total precipitation:‡

Nos.	Weight of gold present in gms.	K C N in gms.	Dilution in c.c.	Current in amperes.	Volts.	Time in minutes.	Weight of gold collected in gms.
1	0.2754	2.5	80	5	8.0 to 7.0	10	0.2746
2	0.2754	2.5	80	5		5	0.2706
3	0.2754	2.5	80	5	7.6 to 6.7	6	0.2720
4	0.2754	2.5	80	5	7.5 to 6.7	8	0.2754
5	0.2754	2.5	80	7	9.5 to 9.0	7	0.2748
6	0.2754	2.5	80	10	11.5 to 13.0	2	0.2667
11	0.2754	2.5	80	15		4	0.2750
12	0.2754	2.5	80	12	19.0 to 12.0	3	0.2621
13	0.2754	2.0	55	12-10	21.0 to 18.0	3	0.2742

This shows that eight minutes are sufficient with a current of 5 amperes, seven with one of 7 amperes, and four minutes with a current of 15 amperes.

A second series shows that with the same experimental conditions, it is not necessary to exceed 10 amperes, as a stronger current causes ebullition of the electrolyte.

Withrow has made, under the conditions he found most favorable, two series of experiments with solutions containing 0.25

*Journal of Amer. Chem Soc'y, XXVI, 1269.

†Journal of the Amer. Chem. Soc'y, XXVI, 1256.

‡Experiments 7 to 10 were excluded, as the author considered them inexact. Further, in experiment 11 he said he experimented with a current of 15 amperes, while the table only stated 10. I have re-stated this figure.

gram and 0.5 gram of gold; the latter are grouped in the following table:

Nos.	Weight of gold present in gms.	K C N in gms.	Dilution in c.c.	Current in amperes.	Volts.	Speed per minute.	Time in minutes.	Wt. of gold found in gms.
1	0.522	5	60	10	10.0 to 8.0	800	10	0.5216
2	0.522	5	60	10.0 to 10.2	10.0 to 7.3	800	12	0.5226
3	0.522	2.5	55	10.0 to 10.8	14.5 to 9.6	800	10	0.5222
4	0.522	2.5	55	10.0 to 10.3	14.0 to 9.4	810	12	0.5234
5	0.5465	3.5	60	10.0 to 10.5	8.3 to 7.0	790	12	0.5461
6	0.5465	5	60	10.0 to 10.2	9.3 to 8.3	790	1	0.1891
7	0.5465	5	60	10.5 to 10.5	8.3 to 7.0	800	3	0.4341
8	0.5465	5	60	10.0 to 10.3	9.6 to 7.1	825	5	0.5286
9	0.5465	5	60	10.0	8.6 to 6.7	780	7	0.5437
10	0.5465	5	60	10.3 to 10.0	8.3 to 6.3	790	11	0.5468
11	0.5465	5	60	10.0	7.8 to 6.8	790	12	0.5467

Experiments 1 and 2 show the precipitation is complete in from 10 to 12 minutes; 3 was made to show the effect of decreasing the quantity K C N; in this case it formed a deposit on the anode like yellow pollen, soluble in concentrated hydrochloric acid. Withrow obtained this deposit in his control experiments with a fixed anode when the precipitation lasted more than two hours.

Withrow obtained very good results by replacing potassium cyanide by sodium sulphide; but to work with this mixture it is necessary to put the sulphide first in the electrolytic cell and not to add the chloride until the anode is in motion. The results of experiments with a solution containing 0.25 grams of gold were within a trifle the same whether using cyanide or sulphide. In the latter case 0.5 gram of gold was deposited in twelve minutes.

Exner was the first to use the rotatory anode for the determination of tin. L. Witmer* used this method in the case where the electrolyte was ammonium sulphide. The ammonium sulphide was run from a burette into the electrolytic cell, then the salt of tin was introduced, and then sufficient water to make up a total volume of 100 c.c. was added. The anode was then put in motion and the current sent through the apparatus. The deposits of tin were washed with water, then alcohol and then ether. The following table gives the results obtained with stannic chloride; the added water was raised to boiling; the deposited tin, weighing 0.5 gram, was gray and crystalline; the anode revolved at a speed of

*Journal of the Amer. Soc'y. 1907, XXIX, 473.

350 to 400 revolutions per second. It was noticed that there was a very rapid precipitation of tin during the first ten minutes, then a sudden fall lasting during the deposition of the last traces of the metal:

Nos.	Quan. of sulphide in c.c.	Amp's.	Volts.	Time in minutes.	Tin collected in gms.	Nos.	Quan. of sulphide in c.c.	Amp's.	Volts.	Time in min's.	Tin collected in gms.
1	25	5	7.5	30	0.5069	9	20	5	9	2	0.1270
2	25	5	8.0	30	0.5067	10	20	5	9	3	0.1922
3	20	5	9.0	30	0.5070	11	20	5	9	4	0.2475
4	20	5	9.0	20	0.5067	12	20	5	9	5	0.2927
5	20	5	9.0	20	0.5064	13	20	5	9	10	0.4796
6	20	5	9.0	20	0.5070	14	20	5	9	15	0.7917
7	15	5	10.0	25	0.5067	15	20	5	9	20	0.5070
8	20	5	9.0	1	0.0704						

When the weight of tin collected is one gram or over, the results are very high. This does not appear to be due to occluded water. Witmer has electrolyzed solutions of variable richness in tin and found that there was nothing occluded so long as the deposit did not exceed 0.8 gram, but above this weight the quantities of tin deposited were too high. He concluded that when using a rotating anode, and ammonium sulphide as the electrolyte, tin could be determined rapidly; that the deposit of tin was produced more rapidly by heating the electrolyte, but the presence of poly sulphides must be avoided, as they exercise a retarding influence.

Julia Langness* used a different anode from Exner, whose, as is known, was of a spiral form. The new anode consists of a platinum cap (or cover) seven centimeters in diameter and three centimeters deep, pierced with ten apertures each 1.8 c.m. long and 0.5 c.m. wide; the base is also pierced with a hole 1.3 c.m. in diameter; thus the free circulation of the liquid is assured. It should be equidistant from the walls of the cathode. The dilution should be weaker than with the spiral anode, for during the rotation of the anode, the liquid is forced into the space bounded by the cathode and the exterior wall of the anode. The volume of the electrolyte should not exceed 65 c.c. Julia Langness has studied the determination of different metals and has examined different electrolytic separations with the help of this anode.

In the case of copper the two anodes, spiral and cap, have been used in comparison with each other; among the numerous experiments that have been made we quote the following: 25 c.c. of cop-

*Journal of Amer. Chem Soc'y, XXIX, 459.

per sulphate, to which were added 1.2 grams ammonium nitrate and 25 c.c. of ammonia, were diluted to 125 c.c., raised to boiling and electrolyzed; with a spiral anode (current of 9 amperes under 8 volts) the precipitation was completed in fifteen minutes; with the new anode (current of 17 amperes under 6 volts) 0.4824 grams of copper were deposited in six minutes. The solution contained 0.4967 gram of copper.

Silver has given good results; silver was precipitated from a solution of nitrate and redissolved in potassium cyanide and two grams of cyanide were added in each case, the electrolyte was then diluted, raised nearly to boiling and electrolyzed. The following results were obtained with Exner's anode (shown in the first table) and with the new anode (second table):

Nos.	Volts.	Amp's.	Time in minutes.	Wt. of silver found in gms.
1	5	2.8	1	0.2046
2	5	2.8	2	0.3391
3	5	2.8	3	0.4858
4	5	2.8	4	0.5043

Nos.	Volts.	Amp's	Time in minutes.	Wt. of silver found in gms.
5	5	2.8	5	0.5225
6	5	2.8	7	0.5270
7	5	2.8	10	0.5301

The precipitation was completed in ten minutes. Here are the results with the new anode, the differences of the current are largely due to the variation in the distance of the electrodes:

Nos.	Volts.	Amp's.	Time in minutes.	Wt. of silver found in gms.
1	5	10	4	0.5304
2	5	6	4	0.5306
3	5	8	3	0.5306

Nos.	Volts.	Amp's.	Time in minutes.	Wt. of silver found in gms.
4	5	9	2	0.5304
5	5	9	1	0.5116

Some trials made with nickel showed that it was possible to precipitate 0.5 grams of metal from a solution containing ammonium sulphate in five minutes.

In the case of zinc, Julia Langness precipitated 0.25 gm. of metal in three minutes with a current of 13 amperes under 6 volts, the solution containing 4 grams of NaOH.

Platinum is deposited very well electrolytically, but it requires considerable time; this factor is considerably reduced by the new method, the metal is entirely precipitated from 25 c.c. of solution of potassium chloroplatinate with a current of 16 amperes under 10 volts.

But the best resuits are certainly obtained from palladium; the electrolyte was a solution of palladium ammonium chloride in

ammonia, 10 c.c. containing 0.268 gram of palladium. The following table gives a resumé of the experiments made, 20 c.c. of solution, to which 20 c.c. of boiling ammonia were added, and the whole then diluted to 60 c.c. with boiling water:

Nos.	Volts.	Amp's.	Time in minutes.	Wt. of palladium found in gms.	No.	Volts.	Amp's.	Time in minutes.	Wt. of palladium found in gms.
1	15	14	3	0.5358	3	17	11-20	1	0.4966
2	17	14-20	2	0.5357					

Rhodium deposits best from a solution of the double rhodium sodium chloride, $Na_2 Rh Cl_6$, to which a few drops of sulphuric acid are added. Julia Langness gives the figures grouped in this table:

Nos.	Volts.	Amp's.	Time in minutes.	Wt. of rhodium found in gms.	Nos.	Volts.	Amp's.	Time in minutes.	Wt. of rhodium found in gms.
1	7	8	15	0.0577	5	8	15	4	0.0573
2	7.5	8	10	0.0580	6	6.5	11	4	0.0563
3	8	9	10	0.0575	7	7	11	4	0.0567
4	8	9	7	0.0576					

The spiral anode was used in experiment 1. In the second part of the work Julia Langness studied the separation of different metals; 1st, gold from platinum and palladium; 2d, copper from platinum; 3d, silver from platinum, from copper, from nickel, from zinc, from a mixture of copper and platinum, and from copper in the alloy for coins.

Smith & MacCutcheon* have used the rotatory anode in a most interesting manner. It was found that in electrolyzing a solution of an alkaline chloride, as neutral as possible, with a rotatory silver anode and a mercury cathode, a colloidal solution of the hydroxide could be produced. If, for example, a solution of cerium chloride is placed in Hildebrand's apparatus, and is electrolyzed by a current of 0.8 to 0.02 amperes under 8 or 10 volts, a cerium amalgam is formed. This amalgam decomposes when all the chlorine has gone to the silver electrode, and the liquid in the interior compartment of the apparatus assumes a red color by transmitted light, it now contains a collodial compound of cerium. This compound gives the following re-actions:

With ammonia—red-brown precipitate.

With sodium chloride—red-brown precipitate.

*Journal of the Amer. Chem. Soc'y, 1907, XXIX, 1455.

With Potassium hydrate—after the addition of a dilute solution; the false solution assumes a pale brown tint, no precipitate; after treatment with permanganate and ammonia, a brown precipitate forms resembling cerium hydroxide.

Potassium chromate—red-brown precipitate.

Potassium iodide—red-brown precipitate.

Stannous chloride—red-brown precipitate.

Hydrogen peroxide—red-brown precipitate.

Hydrogen peroxide and ammonia—yellow precipitate, resembling hydrated cerium dioxide.

This red-brown precipitate which is formed when a salt is added to the mock solution is a mixture of oxides.

If the electrolysis is made with a rotary anode, no colloid is formed but a white precipitate of ferrous hydroxide appears. The colloid forms best with a difference of potential of 8 volts. With a smaller voltage (from 3 to 5 volts) nothing is produced; with a greater, there is a rapid precipitation.

False solutions of hydroxides can also be produced by the electrolysis of the chlorides of lanthanum, neodymium, præseodymium and yttrium; also of ferric chloride.

The electrolysis of a solution of aluminum chloride gives, almost at once, a white, gelatinous precipitate; the filtrate is opalescent and remains so several weeks. Sodium chloride gives a precipitate soluble in sodium hydrate. Chromium chloride, using a current of 0.9 amperes under 5 volts, seems to form a colloid, sodium chloride precipitating chromium hydroxide.

These are the only chlorides with which Smith & MacCutcheon obtained good results. It appears that colloids can only be obtained from the sesqui-chlorides.

ABRASIVE GARNET PRODUCTION IN 1906.

The production of abrasive garnet in the United States in 1906 amounted to 4650 short tons, valued at $157,000. This falls short by 400 tons in quantity but exceeds by $8,905 in value the production in 1905, which was 5050 short tons, valued at $148,095. The average price per ton was $33.75, which is the highest since 1902, and a large increase over the average in 1905—$29.32. The production came chiefly from New York, a part coming from Pennsylvania.

No production of garnet was reported from North Carolina in 1905, but reports published in the mid-summer of 1907 indicate that the output for this year will be large, as the mine in Madison County is being operated with an estimated production of 125 tons of garnet a month. The product of this mine is used chiefly for abrasive purposes, though several very fine, clear gem stones are said to have been found.

Notes On Theory and Practice of Evaporation.

By Philip B. Sadtler, S.B.

THEORETICAL CONSIDERATIONS.

Heat Transmission.—Heat transmission is measured by four fundamental factors, namely, temperature, weight, space, and time. To be more specific, the common combination of units, in which we express heat transmission, is British Thermal Units, per square foot, per hour. Therefore, the coefficient of the heat transmission of a medium would be the figure which gives the number of British Thermal Units passing per hour from a warmer to a colder substance through one square foot of the medium for which we desire the coefficient.

It will readily be seen that the ability of the medium to transmit heat in a greater or less degree is governed by the following factors, namely, nature of the material, thickness of the medium, difference in temperature of the warmer and the colder substance, hence, we have

$$h = k \frac{t - t^1}{d} m.$$

When h = heat transmitted, m = time during which transmission takes place, d = thickness of the transmitting medium, $t - t^1$ = difference in temperature, and k = constant dependent on the nature of the material.

From the above we see that,

$$k = \frac{d \times h}{(t - t^1)m}$$

whence we are able to determine constant k for any material by determining, d, h, $(t - t^1)$ and m for one square foot of heating surface. For practical purposes, where for a given material the limits of the factor d are quite narrow this is omitted and the constant becomes

$$k = \frac{h}{(t - t^1)m}$$

In the case of the transference of heat from one substance to another, for evaporative purposes, we have several possibilities:

that of heat passing *from* a liquid; *from* steam or *from* other gases; also heat passing *to* a body of liquid or *to* a film of liquid.

In evaporation work the case of heat passing from a liquid is not of very wide importance. Other things being equal k would be high in this case, but the difficulties involved in this method of heating necessarily outweigh those of steam heating. A high boiling liquid may be heated and made to pass through heating tubes, giving a high transference constant, but the velocity necessary for its passage through the tubes is great enough to make the idea unworthy of consideration.

In the case of saturated steam there is no necessity for an appreciable velocity directly in relation with the walls of the heating tubes. Unlike the case of direct heating, the effect is obtained by the latent heat of vaporization. Although the heat in large part is not due to difference in temperature between the steam and the liquid, being heated, there must be a quite appreciable difference in temperature to make effective use of the latent heat. The larger the difference in temperature the greater is the heat transmission of the metal walls.

As water dissolves air to a small extent the steam from the boiler always contains air in greater or less amount. This air tends to lessen the heat transmission so that it will be found in practice that better boiling takes place in the heating coil, where the velocity is considerable.

It can readily be seen, therefore, that the presence of *air in the heating steam is detrimental.* Just as air reduces the heat transmission so also does the water produced by condensation of the steam. The heat conductivity of water is far below that of a metal, so that a *steam coil containing a layer of water is not fully effective.*

The usual case of heating by other gases than steam is direct firing of boilers or evaporators, or the utilization of waste heat from furnaces, incinerators, etc. Here the transmission of heat is due to the difference in temperature and *the velocity of the gas.* It will readily be seen that if a body of cooled inert, non-condensable gas stays in contact with the wall of the heating surface the efficiency of the locality where that takes place is greatly reduced. On the other hand, in the case of steam the pressure back of the heating steam is cause for constant supply of the steam, which gives up its latent heat to the wall of the heating surface. A non-

condensable gas, to be equivalent in effect to a condensable gas, like steam, must be led against the heat transferring wall with considerable velocity to cause the rapid removal of cooled gas and prevent lodging of cooled gas in any small corners or devious places.

It is well recognized that the presence of moisture in non-condensable gases materially increases the heat conductivity. Waste gases from the combustion of very wet fuel or from the incineration of wet materials will contain very high percentages of steam and should not be overlooked as a good source of heat for evaporative purposes where their utilization is possible.

In such a case, however, we have usually a mixture of combustion gases and super-heated steam. The latter does not condense, but leaves the apparatus in a slightly cooled condition, because if the passage of the gas against the heating surface were regulated to cause a condensation of this super-heated steam, the velocity would be so low that the heat transmission would be too small for practical evaporative purposes. It is usually desirable, in using waste gases, for evaporation, to work between such limits as 650° and 375° or thereabouts.

Very little can be determined as to the theoretical side of the transmission of heat *to* different solutions and solids. In general it may be said that the completeness of the circulation of the liquid; the consequent rapidity of the disposal of the steam formed at the contact between the liquid and the heating surface; and the degree of mobility of the liquor are the chief factors for consideration here. More can be said later of interest and of value from a practical standpoint.

The heat transmission may be said to be greater when the liquid is in contact with the heating surface in as thin layers as possible. This is accomplished by allowing the liquor to spray or trickle over the heating surface or by bringing the liquor in contact with the surface in the form of a foam. When a film is in contact with the heating surface the evaporation may be said to be local, hence there is a local cooling tendency and consequent greater temperature difference between the liquor heated and the heating gas. This it will be seen will increase the heat transmission.

Single Vacuum and Multiple Effect Evaporators.—The purpose of the single vacuum evaporator is to accomplish a maximum amount of evaporation by taking advantage of the low boiling

point that is produced in liquids under a vacuum. If steam at five pounds pressure is introduced into the steam tubes of an evaporator in which the liquid is allowed to boil at atmospheric pressure the temperature difference between this steam and the boiling liquid (if the latter has the boiling point of water) is about 16°F. If, however, a vacuum of 25″ is maintained above the liquid to be evaporated the temperature difference is about 95°F., or some six times as great as in the above case. Thus for a given

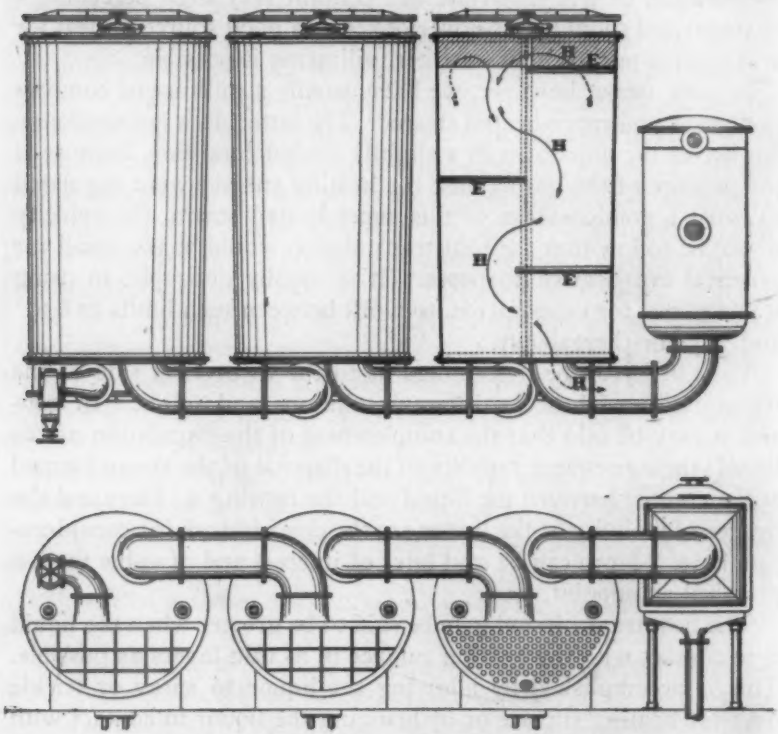


Fig. 1

vessel six times the evaporation can be accomplished in a given time, or for a given amount of evaporation the heating surface in the vessel may be one-sixth the size.

However, most liquids boil readily in an evaporator with smaller temperature differences than that just mentioned, namely 95°. So that the multiple effect system is used to a large extent for the

sake of economy. It is based on the utilization of the latent heat of the vapor arising from the evaporating liquor, to bring about further evaporation by heating the tubes of another evaporator. If the absolute pressure in each effect of the series is markedly lower than in the preceding effect, there is always obtained a temperature difference between the vapor of one effect and the liquid of the next.

For example, in the triple effect system shown in Fig. 1, let it be supposed that the steam enters the heating tubes in the bottom of the first effect (a) at atmospheric pressure, and that in the vapor spaces of the three effects have maintained in them vacua of 8, 16 and 24 inches. Then the temperatures are approximately: steam, 212°; vapor in (a), 195°F.; vapor in (b), 176°; vapor in

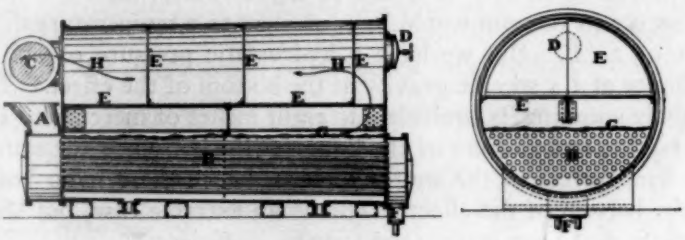


Fig. 2

(c), 140°. The average effect difference is about 24°F., which is quite sufficient for rapid boiling.

It is not difficult to see the economy in this system. The boiling of the liquid in all three effects is accomplished by the introduction of steam into the one. Theoretically there is accomplished an evaporation of three pounds of water per pound of steam entering the system. In actual fact due to radiation losses, etc., this figure is slightly under 3 pounds or above 2.7 pounds.

The amount of evaporation accomplished is due to, (1) the temperature and pressure of the entering steam; (2) the temperature and pressure of the steam produced in each separate vessel; (3) the extent to which the liquid is to be thickened by boiling and the nature of the liquid; (4) the height of the boiling layer of liquid in each vessel.

Fig. 2 gives an idea of the depth of the liquor in an evaporator for the best results. Evaporators having heating surface at the bottom of a very deep layer of liquor can not attain the greatest

efficiency. If the depth is considerable and if the liquid is of high gravity there is so great a hydrostatic pressure at the bottom of the liquid that its boiling point is thereby greatly raised. Unless the effect temperature difference is very great, the temperature at the bottom of the effect may be too high for the proper heat transmission. On the other hand, if the apparatus of the deep liquor layer is pushed to obtain the proper evaporation, the boiling point at the bottom is so great compared with the temperature in the vapor space that ebulition is violent and liquor is thereby lost.

For example, if we assume a case where the layer of the liquor is six feet deep and having a specific gravity of 1.4. Assume as in the above case that the vacuum is eight inches higher than in the preceding effect. It would be expected that the eight inches difference in vacuum would be equivalent to a temperature difference of 24°F. But we have a hydrostatic pressure of six feet of liquor at 1.4 specific gravity at the bottom of the effect. This, roughly speaking, is equivalent to eight inches of mercury. Thus the boiling temperature of the liquor at the bottom is the same as the temperature of the source of heat, hence there is no boiling in the bottom of the effect. This is an extreme case, but serves to show that deep layers tend toward inefficiency.

To be continued.

BUHRSTONES AND MILLSTONES.

The buhrstones and millstones produced in the United States in 1906 were valued at $48,590, an increase of $10,616 over the value of the output in 1905, though still below the records for 1901, 1902, and 1903, in each of which the value amounted to more than $50,000.

Though stone suitable for buhrstones and millstones is found in a number of States, only four—New York, Virginia, North Carolina, and Pennsylvania—reported production in 1906, the State values being as follows: New York, $28,848; Virginia, $[illegible]611; North Carolina, $1,507; Pennsylvania, $2,624.

The value of the imports of these abrasives into the United States for each of the last three years has been approximately $32,000.

The production of abrasive materials in the United States in 1906 is the subject of a report by Douglas B. Sterrett, geologist, of the United States Geological Survey, published as an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," and now ready for distribution by the Survey.

The Relation of Magmatic Waters to Volcanic Action.

By Hiram W. Hixon.

The relation of magmatic waters to volcanic action, ore deposition, mountain folding and kindred phenomena has not been fully appreciated, and with few exceptions has not been recognized as of any importance. A glance at the table of analyses of eruptive rocks, taken from Kemp's Handbook of Rocks, will show the large amount of combined water which these rocks contain.

	IGNEOUS ROCKS. THE GLASSES.								Loss.
	SiO_2	Al_2O_3	Fe_2O_3	FeO	CaO	MgO	K_2O	Na_2O	H_2O
1 Pumice, Cinder Cove, Cal.	79.49	11.6	0.33	0.49	1.64	0.09	1.52	4.04	0.68
2 Black Obsidian, Tewan Mounts.	76.20	13.17	0.34	0.73	0.42	0.19	4.46	4.31	0.33
3 Red Obsidian, Yellowstone	75.52	14.11	1.74	0.08	0.78	0.1	3.63	3.92	0.39
4 Black Obsidian, Yellowstone	74.70	13.72	1.01	0.62	0.78	0.14	4.02	3.9	0.62
5 Obsidian, Mono Lake	74 05	13.85	Fr.	.....	0.90	0.07	4.31	4.6	2.20
6 Obsidian, Lipari Isl.	74.05	12.97	2.73	.....	0.12	0.28	5.11	3.88	0.22
7 Obsidian, Clear Lake, Cal.	74.01	12.95	.....	1.42	0.99	0.48	4.65	5.34	0.29
8 Perlite, Hungary	72.87	12.05	1.75	.....	1.30	1.1	Fr.	6.13	3.00
9 Pitchstone, Mussen	71.6	12.	1.0	.....	1.1	0.2	4.3	2.5	7.14
10 Pitchstone, Silver Cliff, Col.	71.56	13.10	0.66	0.28	0.74	0.14	4 06	3.77	5.52
11 Andesitic Perlite, Eureka, Nev.	65.13	15.73	2.24	1.86	3.62	1.42	3.96	2.93	2.43
12 Obsidian, Teneriff	60.5	19.1	4.2	0.3	0.6	0.2	3.5	10.6	.....
13 Hyalomelene, Germany	54.28	14.83	14.73	.....	7.02	3.65	1.27	4.22	.....
14 Pele's Hair, Hawaii	50.82	9.14	7.33	7.03	11.63	7.22	1.02	3.06	1.74
Rhyolites, Average 14									1.21
Trachytes, Average 6									1.38
Phonolites, Average 8									1.45
Granites, Average 12									0.6
Syenites, Average 7									1.2
Nipheline Syenites, Average 10									1.37
Basalts, Average 10									1.84
Diorites, Average 8									1 88

The combined water is shown as loss on ignition, and varies from 6/10 per cent. in granite to 7.4 per cent. in pitch-stone.

If we assume that the interior of the earth is made up of materials in the proportions found in these igneous rocks we are

forced to the conclusion that there is much more water in the interior magma than there is on the surface. None of the igneous or plutonic rocks shown in these tables contain less than 1/10 per cent. of combined water and even with this amount the water contents of the interior magma would be in excess of all the water in the oceans, lakes and rivers. Anyone who wishes to demonstrate the existence of water in fused lava has only to travel to the nearest active volcano and observe the expansion of steam and the formation of cavities in the molten mass. Not only is this possible, but if a piece of pitchstone or obsidian be placed in a forge and heated to a white heat, it will expand by the force of the contained water, and will be found to have passed into a kind of pumice. If the heating is stopped at the right time a core of unaltered pitchstone will be found, surrounded on all sides by a shell of expanded material. It is generally recognized that steam is the prime cause of volcanic action; the main point of difference of opinion has been the source from which the steam is derived.

Nearly all writers on this subject have held that the water was derived from the surface, either by being deeply buried in sedimentary rocks, or by passing through porous rocks against a pressure of steam, or by fracture of the ocean bottom.

Judd recognized the possibility that the water was a part of the original magma, and was given off on cooling in a manner similar to the discharge of oxygen by refined silver when cooling.

This statement is made in his work on Volcanoes, published in 1881, and is probably the earliest reference to the subject of magmatic waters.

The object of this paper is to elaborate the idea, and to show how it is possible that the water should have become a part of the interior magma; as well as its influence on all the geological and geographical structure of the earth.

It is necessary to go back to the beginning of things, in order to get a grasp on the conditions which made it possible. According to the Nebular Hypothesis, which is generally accepted as being the only satisfactory explanation of earth's genesis, the earth is an aggregation of matter from a nebula of matter in a dispersed form. According to our present knowledge expansion or dispersion causes lowering of temperature and aggregation or compression causes increase of temperature. Therefore, as the matter composing the earth gravitated towards a com-

mon center, the increase of temperature became sufficient to fuse and probably gasify or volatilize all of the matter of which it was composed. By the law of diffusion of mixed gases we find that they diffuse uniformly through the space occupied, without regard to the presence of other gases.

We also know that at high temperatures and under great pressure, gases are absorbed by solids and liquids, and that these are given off on cooling. Copper at high temperature in a converter contains several times its own volume of SO_2, and this is given off, when the charge is poured into moulds, and causes miniature volcanoes, ejecting copper in place of lava when a crust has formed over the surface. According to the law of uniform diffusion of mixed gases, whatever the mixture of gases which composed the earth in its earliest development, the mixture would be homogeneous until it began to cool. As cooling would begin at the surface the segregation of material would take place there according to the relative points of condensation. As nearly half of the matter composing the earth is oxygen, it would follow that there would always be a sufficient supply to combine with the small proportion of hydrogen present, and therefore we may assume that either in fact or in substance, water existed as a permanent gas above its critical temperature throughout the highly heated magma of the interior. As to the condition of this magma whether solid, liquid, or gaseous, we cannot claim to know much. This, however, we do know; it is highly heated, and according to our present knowledge of the increase of temperature with depth, we are justified in assuming that at a depth of 100 miles below the surface the temperature is as much as five thousand degrees centigrade, or nine thousand degrees fahrenheit.

This is about the critical temperature of all known substances, and as the critical temperature of a substance is defined as "the temperature at which it will remain a permanent gas, no matter what the pressure may be," we are justified in assuming that, regardless of the density due to pressure, all the magma at that depth is potentially, if not in fact, of a gaseous nature. It has been demonstrated that the viscosity of a gas increases with the pressure; and therefore, where pressures are measured in thousands of tons per square inch, it is possible for gases to acquire rigidity as great as solids, so long as the pressure is maintained.

Rigidity is a property of solids produced by cooling. Cooling causes reduction of the amplitude of vibrations of the molecules of matter with relation to each other. If a gas is subject to sufficient pressure to produce a greater density than if it were a solid, it is conceivable that it should acquire greater rigidity by the reduction of the amplitude of vibration of its molecules so long as the pressure is maintained. It is therefore possible that the interior magma may be gaseous and still have the required rigidity to resist tidal action. Assuming this condition of matter to exist in the interior, and at a depth of less than one hundred miles below the surface, it is possible to trace out some of the effects that would follow upon the loss of heat and the tendency of the water to travel toward the surface. First of all would be the formation of an atmosphere of incandescent steam and other gases, which would keep increasing in thickness and density as more and more of the magmatic water came to the surface. The substances which liquefied at the highest temperature would separate out at first as fine particles, much in the nature of fog or mist. This would go on accumulating until there had formed a sufficient quantity of the material to fall as rain, and be revolutionized by the ardent heat of the gaseous magma. Liquid areas of this molten material would form, supported by the gases of greater density, and constantly torn to tatters by eruptions of gases through them. In time a solid crust would begin to form over the liquid area, and this crust also would be torn and shattered by eruptions; until by accumulation of fragments it would cover the greater portion of the surface, the remainder being occupied by great boiling lava lakes, hundreds of miles in diameter. The craters of such volcanoes as then existed would dwarf all present craters. By continued escape of the magmatic steam the activity of these crater areas would be gradually decreased and the surface would be cooled until condensing water began the disintegration of the lavas and the formation of sedimentary rocks. By the process of eruption, disintegration and deposition, repeated throughout almost infinite time, we arrive at the present conditions. The question which interests us most is not how all this happened so many millions of years ago, but what bearing has it on the present? The most remarkable effect of the discharge of magmatic waters is volcanic action. The elevation of the zone of flowage due to rise of temperature is effected by heat

supplied from below by means of steam diffusing upward through the magma and accumulating below the zone of fracture.

Before proceeding further it is advisable to understand what we mean by steam at a temperature of 5,000 degrees centigrade and pressure of 45,400 atmospheres which corresponds to a depth of 100 miles. We know that one cubic inch of water will make a cubic foot of steam at atmospheric pressure and a temperature 100°C. Therefore $\frac{1}{1728}$ = density of water gas at one atmosphere = $\frac{6}{10000}$. We know that the density of a gas will vary directly as the pressure and inversely as the absolute temperature. Expressing this in symbols we have

$$D = \frac{6}{10000} \times \frac{45400}{1} \times \frac{373}{5273}$$

Therefore $D = 1.91$.

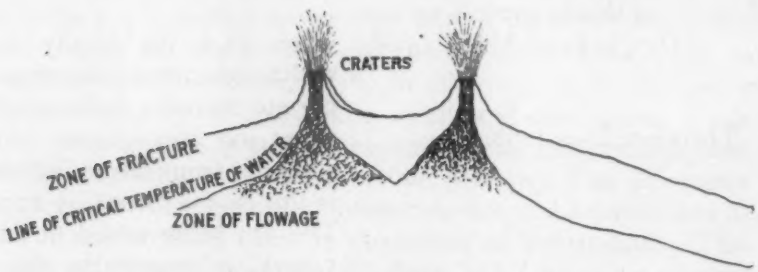
where D is the density we wish to determine P the pressure at 100 miles depth equal to 45,400 atmospheres. At absolute temperature which in this case is 5,000 C + 273. The 273 being added to the 5,000 C. to convert the absolute temperature.

This density is greater than water on the assumption that water above the critical temperature of 365 C. is a perfect gas and subject to the law which is assumed to apply beyond the limits of our present knowledge.

The steam is assumed to collect and pass upward toward the zone of fracture by diffusion through the zone of the flowage. Below the zone of flowage is the zone of potential gas in which all the materials are assumed as being equally diffused according to their relative abundance. The gases which condense to solids at high temperatures add to the thickness of the zone of flowage, the magmatic steam, hydrocarbons, SO_2, CO_2, HCl and other gases, diffuse toward the surface through the material with which they can no longer be associated because of its changed condition. The segregation of the materials of the central magma is caused by secular cooling and the different behavior of its constituent gases due to their varying critical temperatures. As the steam travels toward the surface it is subject to less pressure and it therefore expands until it finally condenses to water or is discharged as steam at atmospheric pressure. After the steam has collected sufficient heat and pressure to rupture the zone of frac-

ture, it penetrates along fault planes into rocks in which the temperature is below the critical temperature of water, and in which it ceases to act as a perfect gas and begins to condense to water, with the accompanying shock due to water hammer, and the opening and closing of the fault places.

These sudden collapses of steam, while elevating the zone of critical temperature, produce the earthquakes which immediately precede an eruption and announce the approaching danger. The final outburst is frequently preceded by a large discharge of mud


CRATERS
ZONE OF FRACTURE
LINE OF CRITICAL TEMPERATURE OF WATER
ZONE OF FLOWAGE
MAGMA ABOVE CRITICAL TEMPERATURE OF ALL SUBSTANCES
POTENTIALLY GASEOUS, CONTAINING WATER GAS

Ideal section of volcanoes actuated by magmatic steam, showing intersecting zones in which steam collects beneath each crater, illustrating how they act independently of each other. The steam supplying the heat necessary for fusion of the lava which may come from any horizon.

and water, after which the steam flows up from below so rapidly as to elevate the temperature of the crater to the fusing point of the rocks along its path. Then begins the discharge of pumice and dust followed by scoria and other lavas more or less dense, and containing less water as the density increases. The first discharge of dust may be simply pulverized rock, or it may be a lava containing so much water as to be atomized by the explosion or expansion of the steam it contains.

As it appears probable that under proper conditions, water and rock are miscible in all proportions, we may expect to find lavas containing so much water that they are atomized by its expansion.

When the accumulated steam has escaped, the lava in the crater flows back into the depths and solidifies, effectively plugging it up until after a long or short period enough steam has collected to

cause another eruption. This blowing out of the lava by the expansion of the magmatic steam is similar in action to the uncorking of a bottle of champagne or mineral water, which, if not properly done, will result in the gases discharging the contents of the bottle before the operator is prepared for it.

In places where the magma, supersaturated with steam, has been carried into fault planes, it becomes dikes, which later may be exposed by erosion or which may accumulate below an elastic rock, such as shale, as lacoliths.

At a depth of seven miles below the surface the temperature is probably about 365°C., which is the critical temperature of water. The density of steam would be 1.1 at this temperature and pressure, according to the law above mentioned. As the zone of flowage and high temperature is much higher under a volcano than under other parts of the crust, it follows that the steam above the critical temperature comes nearer to the surface before condensing. Under the reduced pressure it would expand and be less dense. At a depth of two and a-half miles the pressure would be about 1000 atmospheres if the rock density averaged 3. Under this pressure, and at the critical temperature, the density of steam would be .37. Sudden condensation would, therefore, be accompanied by a reduction of volume, and a sharp shock. At the depth of seven miles, where the density is 1.1, condensation would not take place, because of the higher temperature; and no shock would be possible because there could be no sudden reduction of volume. This explains why the water hammer earthquakes which immediately precede a volcanic explosion, come from shallow depths, as compared to the other type of quakes, caused by faulting, which goes clear through the zone of fracture and may extend to depths of many miles.

The point of relationship between them is that they are both caused by the escape of magmatic waters. In the latter case the fault is due to contraction of the inner magma which supports the crust. This causes the crust to crush and settle by its own weight.

The contraction of the magma is due to loss of heat and steam which escapes towards the surface; and, therefore, this loss of magmatic waters is one cause of earthquakes of both types, as well as one cause of faulting and folding. Faulting and folding, by this theory, are effects, and not necessarily causes. A photo-

graph of the moon will show that the surface is covered with craters on a gigantic scale, much the same as we would imagine to have been on the earth had they not been destroyed by the disintegrating action of water. The diameter of some of these lunar craters is estimated to be as much as eighty miles and the depth thousands of feet. If the discharge of magmatic water is to be accepted as the cause of terrestrial volcanism, what about the moon, where no water exists on the surface? If water existed on the moon, in the course of the long lunar day, when the sun shines on one side for fourteen of our days, water would be boiled, while during the night the degree of frost would expand the ice to such an extent that the disintegrating effect of even a small amount of water would be multiplied many times what it is on the earth.

It would be like having fourteen days of the equator followed by two weeks of the North pole. On the earth we have winter once a year, while on the moon it occurs each month of our time. The water on the hot side would be vaporized and condensed on the cold side, so that if water existed on the moon there would be a constant cloud forming at the line of illumination, and this would be visible even to the naked eye. That no such thing occurs is proof positive that the moon is without an atmosphere of any kind. What has become of it? There have been several suggestions offered to account for the lack of an atmosphere on our satellite, among which are that it has been absorbed by the moon itself, or that a comet came along and stole it away. The real solution of the problem is probably that the kinetic energy of gases is greater than the gravity of the moon can overcome. As fast as gas of any kind was discharged from the craters, it expanded into space, and was eventually taken away from the moon by the greater gravity of the earth. The earth, therefore, has robbed the moon of its atmosprere and hydrosphere and the moon has never felt the effect of disintegration and sedimentation as the earth has. The mass of the moon being only one-eighty-first part of that of the earth, and its force of gravity at the surface only one-sixth, we can understand how the stronger attraction, coupled with the tendency of gases to expand into space, would result in the atmosphere of the moon being picked up, molecule by molecule, and added to that of the earth.

What bearing this theory has on the cause of volcanism on

the earth may now be shown. The presence of past volcanic activity on the moon is unmistakable, and the cause (water) is absent, having been added to the earth as rapidly as liberated. Therefore there was never an opportunity for surface waters to get into the interior of the moon, and to cause the volcanic action which evidently occurred there. But the evidence in the shape of enormous craters are there; and the conclusion is that the magma having parted with its steam, volcanic action ceased. We may, therefore, feel sure that when the earth loses all its magmatic water, volcanic action will cease, no matter how much water may be on the surface.

Of the many other ways in which magmatic waters are producing results which are not generally recognized as caused by them a few may be mentioned.

The water on the surface is being constantly added to by the discharge of steam from volcanoes, water from hot springs, geysers, etc. The ocean areas are therefore being added to unless by the process of folding the depth is increased.

The waters discharged by hot springs and geysers can be proven to be of magmatic origin in several ways.

They contain a certain amount of heat. If we calculate the amount of hot rock required to supply that heat we will find the volume of rock to be so large that the water could not come into such contact with it as would extract the heat. For example, a calculation of this character was made on the water discharged by the geysers and hot springs in Yellowstone Park. And while no claim for great accuracy can be made it was found that it would require the heat from one hundred and forty cubic miles of lava, cooled through fifteen hundred degrees of heat, to furnish the heat in the water discharged in one hundred thousand years.

The discharged waters are known to contain hydrochloric acid and carbonic acid and other ingredients characteristic of volcanic emanation.

Hot springs are distributed along fault planes in the same manner as volcanoes, and while some of the water may be of surface origin, the greater portion is magmatic water. In nearly all cases hot spring water contains so much silica and lime in solution that the deposition of these along the path of ascent completely isolates the spring from surface waters, finally fills the channel

and chokes the spring to death or causes a new one. The water laden with these soluble salts penetrates the rocks in all directions, before reaching the surface and by depositing the minerals from solution acts as a cementing agent on all porous rocks, and isolates its channel as effectively as a casing excludes surface water from an oil well.

The last step in the process of isolation is to build up a cone of geyserite or travestine at the surface.

The minerals in solution may change at different levels, as the waters pass through rocks of different degrees of solubility. Thus, for example, waters that rise through eruptive rocks may discharge through limestone at the surface; and drop their silica and iron in favor of lime while passing through the lime. This is probably true of Mammoth Hotsprings in Yellowstone Park.

The deposition of ores from magmatic waters is a subject that is deserving of more attention than has been given to it, but there are hopeful signs for the future. Surface waters laden with air as an oxidizing agent can alter a sulphide ore body, or deposit such beds of iron as are plainly of sedimentary origin; but they cannot deposit unaltered sulphides. The waters which deposited ores came from depths that surface waters never reach.

The ascension of hot solutions, along lines of least resistance, is the only theory by which rich shoots can be sufficiently accounted for in vein filling.

Dolitimization of limestone, in the vicinity of ore deposits (such as are in southwest Missouri, and at Aspen, Colorado), is another effect of magmatic waters containing sulphate of magnesia in solution. The cementation of sandstone, converting it into a flinty quartzite, is another and more frequent effect. In fact, the influence of magmatic waters is to be found distributed throughout the lithosphere, the hydrosphere and the atmosphere.

It is one of the greatest forces acting upon the earth, and has been given little recognition for the great work accomplished. Mountain folding is a characteristic example. It has been admitted by eminent physicists, who have examined the subject, that it is impossible to account for the contraction necessary to mountain folding by simple secular cooling. If, however, we assume that the greater portion of the water now in the oceans was at one time a part of the central magma, the difficulty disappears. We have also considerable evidence from the analysis of volcanic

rocks that there is still more water combined with the central magma than exists on the surface. From this we may infer that there will be a further reduction of the earth's diameter followed by more earthquakes and mountain folding and kindred phenomena. Besides Prof. Judd, whom I have quoted, Chamberlin, Hill and others have referred to magmatic waters in connection with volcanic action, but have not followed the subject farther than to show the presence of steam as being a feature of the explosion.

Osmond Fisher's Physics of the Earth's Crust, 1889, contains much of the matter in this theory but different in detail. Fisher assumes convection currents in a fluid substratum, for which the above theory substitutes diffusion of the steam and occluded gases through the zone of flowage.

GEOLOGY AND WATER RESOURCES OF THE ATLANTIC COASTAL PLAIN.

Important Cöoperative work Between the State and National Surveys.

A geologic study of the Atlantic Coastal Plain of the United States is being carried on by the United States Geological Survey in cöoperation with the official surveys of the various States concerned. Although the need for such work was long recognized, plans for its inauguration were not perfected until about a year ago, when, in response to an invitation sent out by the Director of the National Survey, the State Geologists from the various States came to Washington and met in conference those members of the Federal organization most deeply interested in the proposed investigation. At this meeting, which was held December 31, 1906, it was decided that the cöoperative Survey of the geology of the coastal plain States should be made, with especial reference to the underground water resources of the region.

In accordance with the views expressed at the conference a Supervising Board was formed, with Professor William Bullock Clark, of Johns Hopkins University, as chairman, the other members being the State Geologists of the cöoperating States and, from the National Survey, the chiefs of the geologic and water resources branches, the Chief Paleontologist, and the geologist selected to supervise the investigation.

The State Geologist of each State has general supervision of the work in his State, while the Chief Geologist, Chief Hydrographer and Chief Paleontologist of the Federal Survey act in their respective official capacities. Mr. T. Wayland Vaughan, the geologist selected to supervise the investigation, has charge of the cöordination of the work between the different States represented and of the geologic correlations.

As a result of many conferences it has been decided to issue for each State cöoperating a report in accordance with the following outline:

1. Topographic description, which will include an account of the surface relief and drainage features.

2. Stratigraphy, including brief descriptions of the various geolgic formations, from the oldest to the most recent, the thickness of the formations, the physical and chemical characters of the rocks composing them, and the geologic structure. This part of the report will also include lists of the fossils that have an important bearing on the determination of geologic horizons.

3. Hydrography, including an account of the stratigraphic distribution of the underground waters—that is, of the geological formations in which the waters occur—a discussion of the amount of supply, qualities, and uses of the waters, and a detailed description of their geographic distribution.

4. Cartography. Each report will include a topographic map of the Coastal Plain region of the State on the scale of 1:500,000 to 1:1,000,000 (that is, approximately, 1 inch = 8 miles or 1 inch = 16 miles), the elevations to be shown by contour lines representing intervals of 50 feet. This map will be used as the base for (1) the areal geological map, which will show the geologic formations by colors and patterns; (2) a hydrographic map which will show the surface outcrop of each water-bearing bed, and, by contour lines of equal elevation, the position of its upper surface with relation to sea level; (3) a hydrographic map showing the water resources for each locality, classified according to source; the important physical and chemical properties of the waters, and the arrangements for distributing the waters for domestic and industrial purposes, i. e., wells reservoirs, etc.

On the plan outlined, the reports can be published either by the State Survey or by the National Survey as may be desired.

The following States are cöoperating in the work:

New Jersey, Prof. H. B. Kümmel, State Geologist.

Maryland, Prof. W. B. Clark, State Geologist.

Virginia, through Prof. W. B. Clark, who is directing a study of the Coastal Plain of that State.

North Carolina, Dr. Joseph Hyde Pratt, State Geologist.

South Carolina, Mr. Earle Sloan, State Geologist.

Georgia, Prof. W. S. Yeates, State Geologist.

Florida, Prof. E. H. Sellards, State Geologist.

Alabama, Prof. Eugene A. Smith, State Geologist.

Mississippi, Prof. A. F. Crider, State Geologist.

Preliminary arrangements have been made for reports on the States from New Jersey to Mississippi, inclusive, and work has been done during the last year in all except Mississippi. Lack of available funds has prevented the execution of all the work as first planned. It is hoped that the studies can be extended so as to include the whole Coastal Plain area of the United States—that is, to extend from Cape Cod southward through the Atlantic States, westward through the Gulf States to the Rio Grande, and northward along the Mississippi to southern Illinois. Should this plan be carried out it will yield a cöordinated history of the physiography, stratigraphic geology, and water resources of this extensive and important area.

Accounts of the work done in accordance with this plan will appear from time to time.

Mining and Metallurgical Section.

(Stated meeting, held Thursday, March 19, 1908.)

Notes On Copper Mining in the American Colonies.*

By Edgar T. Wherry.

The possibility of the occurrence of mineral wealth in the New World naturally attracted the attention of the colonists from the very earliest times. Aside from the fool's gold, which in those days entrapped the unwary, as it does even now, the iron ore with which the country abounded was the first object of mining operations. The beginnings of the iron industry have been well told by many writers, but the search for copper, which also commenced in the early days, has received little consideration. The following data, obtained in the course of a study of the copper deposits of Pennsylvania, seem, therefore, worthy of publication.†

The colony of New Amsterdam was started by the Dutch in 1624, but only fragmentary records of events were preserved at first. From the selections of these copied in Brodhead's History of New York, and Hazard's Annals of Pennsylvania, it appears that the earliest mention of copper occurs in 1659, in the following words:

"We lately saw a small piece of mineral, said to have been brought from New Netherland, which was such good and pure copper, that we deemed it worth inquiring of one Kloes de Rutyer about it * * * . He asserted that there was a copper mine at Meenesink and that between the Manhattans and South River was discovered a mountain of crystal."

In Hazard's Register of Pennsylvania, Volume I, page 439, is

*Part I of paper on Triassic Copper Mines in Southeastern Pennsylvania, as presented at the meeting.

†I am greatly indebted to Mr. George W. Geist for calling my attention to several of the publications herein referred to, and embrace this opportunity to express my thanks for his valuable assistance.

an article headed, "Meenesink, Mine Holes, &c.," in which Samuel Preston describes a surveying trip to Northeastern Pennsylvania, taken in 1787, with the express purpose of "learning more particulars respecting the Mine Road to Esopus," and the Meenesink settlement which had been observed by Nicholas Scull and John Lukens on a visit to the region in 1730.

"At Paaquarry Flat, on the Delaware, above the Blue Mountains," he found a settlement, "the inhabitants being all Hollanders," and one of them, Nicholas Depuis, gave him the following account of the mining operations:

"That in some former age there came a company of miners from Holland; supposed from the great labor that had been expended in making that road about 100 miles long that they were very rich or great people; in working the two mines, one on the Delaware where the mountain nearly approaches the Lower Point of Paaquarry Flat, the other at the north foot of the same mountain, near half way between Delaware and Esopus; that he ever understood that abundance of ore had been hauled on that road, but never could learn whether it was lead or silver."

Preston further learned from New York surveyors whom he met that the Mine Holes and Mine Road were recognized by them as "a work transacted while the State of New York belonged to the government of Holland; and must have begun many years before the English occupation, in 1664."

The Meenesink or Paaquarry Flat locality is situated on the Delaware River, nine miles northeast of the Water Gap. The quartzite of the Kittatinny Mountain carries here considerable amounts of copper and silver, which are being exploited, though with little success, at the present day; and below the recent workings the old tunnels driven by the Dutch are still to be seen.

The "north foot of the same mountain" evidently refers to Ellenville, New York, where copper, lead and zinc were actively mined fifty years ago. Here, also, openings of considerable antiquity are known to exist, and, although usually attributed to the Indians, were probably the work of the Dutch, as above described. In fact, since this is the nearer to the Hudson River, the principal path of traffic in those days, it is very likely that it was the first to be discovered. The "mountain of crystal" noted by De Ruyter was no doubt one of the veins of crystallized quartz, so common in the Kittatinny Ridge.

A somewhat similar problem is presented by the Solebury copper mine on Bowman's Hill, two miles south of New Hope, Bucks County, Pennsylvania. From Battle's History of Bucks County the following description is taken:

"The main shaft, running northwest from the entrance, is four feet wide by seven feet high; sixty feet from the entrance it crosses a chamber about fifteen feet in diameter, seven in height, with a stone pillar near the center. The drift extends twelve feet eastward from the chamber. To the right of the latter is the main shaft to the surface, six feet in diameter and about thirty in height, which descends through the chamber to a depth of twenty-two feet; and at the bottom a second drift is encountered extending northward fifteen feet. A tradition concerning the existence of the mine has always been current in the neighborhood. * * It was discovered and explored by John T. Neely in 1854.

"The land was originally seated by William Coleman, sold to a company, by them to Robert Thompson in 1753, reserving the right to dig for copper, lead, or iron ore. * * * There is no evidence that they or any subsequent purchasers made the original excavations. Indian tradition asserts most clearly, however, that 'white men' worked the mine. Who they were, whence they came, and what disposition was made of the minerals they extracted are among the secrets of history."

Now it is true that no mention of this mine is made in the records of New Netherland. But it seems quite reasonable to suppose that the Dutch, guided, of course, by the Indians, traveled sixty miles down the river from Meenesink to seek for ore here also.

That copper mining engaged the attention of the settlers in New England at an early date is generally recognized. Thus in the Records of Massachusetts for October, 1651, we find the following note:

"Upon the request of our present Governor, John Endecott, Esquire, this Court doth graunt him three hundred acors of woodland, tendinge to the furtherance of a copper worke he intends to set up in a place called Blind Hole neere to a farm formerly graunted him, the said land not being formerly graunted, provided he set up his said works within seven years."

It appears, however, that the said works were not set up, for no later mention of this locality can be found.

A more successful enterprise was that near Simsbury, in Connecticut. The deposit was discovered about 1705, and operations were begun in 1709 by the first mining company chartered in America. The results were at first somewhat disappointing, for in 1718 the Records of the Colony say:

"* * * The copper mines within this colony, by the orderly and effectual management of them may in time to come be of great use and advantage * * * although at the present time they be of small advantage to anybody, and a fruitless expense of money to the proprietors * * * *."

The later history of the mine,—the coining of the Granby coppers from the metal obtained, and its use as a prison during the war,—is so well described in the various stories of the colony that no further account need here be introduced.

Although the Solebury mine can claim precedence in Pennsylvania, as far as actual date is concerned, the first mines opened by the English (and German) colonists were destined to become of far greater importance. The deposits must have been discovered almost immediately after the first settlement, for William Penn, in writing to Lord Keeper North and other friends in England, in 1683, mentions the existence of "mineral of copper and iron in divers places."

As to the year in which mining was begun local historians are not entirely agreed, and although it is often given as 1720, there are some suggestions of activity at an earlier date. In 1703, the deputies of Penn had granted to Nathaniel Puckle a tract of "four hundred and fifty acres of land fronting on the present northeast line of Limerick, * * * in the southwestern portion of the present Township of Frederick," described as rough and unimproved;* and it seems not improbable that some work was carried on at that time, although it is not until 1722 that we find Roger Edmunds, son-in-law of Puckle, organizing a company to operate the copper mines. This company was unsuccessful, and the next year they were sold out by the sheriff to Andrew Hamilton, Esquire, of Philadelphia. He in turn formed an association among his friends, under the title of the Perkiomen Mining Company, but no extensive development of the property was undertaken until about 1740.

*Bean's History of Montgomery County, p. 843.

Christopher Geist, a German mining engineer, was then brought over to carry on the work, and drove a tunnel westward from the Perkiomen Creek to a distance of over 2000 feet; it there connected with three shafts and with a drainage tunnel opening on Mine Run, which is still accessible and can be followed in for some distance. Sufficient ore was obtained and sent to England to justify its inclusion among the principal exports of the Province of Pennsylvania by Sir Charles Whitworth,* but about 1770 the mine was closed, the property sold and the locality forgotten. Scull's map of Pennsylvania of 1759 shows two mines in this region, the one just described and a "Caledonia mine," about two miles to the northwest, of the history of which nothing is known.

It is, however, not only in the Records of the Province of Pennsylvania that information concerning these early mines is to be found. A German journal, the Breslau Kunst und Natur Geschichten (Supplement III, page 46) published about 1720, contains an interesting, though rather rambling and indefinite account of them. In this, particular reference is made to a copper deposit discovered in 1717 on a tract of land called New Hanover, by John Henry Sprogel, the ore from which had been assayed by Herr Marggraff, of Berlin, and found to contain, in four ounces, one ounce of metallic copper and four grains of gold, which the writer, "a learned physician of Frankfurt-on-the-Oder," wisely considers "so strong that it would be safe to neglect the copper and count upon the gold." Sprogel's property is at present the Brendlinger farm, about three miles east of Boyertown; several openings are still visible there, but whether they were made by Sprogel, by Geist, or by later workers is unknown.

The account also states that other mines had been opened about the same time (1717), evidently referring to the Perkiomen mine, above described, and perhaps to the Gap mine, in Lancaster County, which, according to another authority, dates from 1718.† And finally, it mentions the finding of copper "by a moor" on the Schuyler farm, in "West Jersey, ten miles from New Yorck," in 1714. The Schuyler mine therefore antedates these various Pennsylvania mines, with the possible exception of the Perkio-

*An account of the trade of Great Britain, London, 1776.

†Doble, C. Annual Report of the Secretary of Internal Affairs of Pennsylvania, 1875.

men; but nothing can be added to the excellent account of it which recently appeared in these pages.*

As a summary of this paper the following table is introduced, including all of the copper mines believed to have been opened in the American Colonies before 1725, with the approximate dates when operations were begun. But as the incompleteness of the records renders the exact order uncertain, the list must in no way be regarded as final:

Ellenville	New York,	before 1650.
Meenesink,	New Jersey,	before 1650.
Solebury,	Pennsylvania,	before 1650.
Simsbury,	Connecticut,	1709.
Schuyler,	New Jersey,	1715.
Perkiomen,	Pennsylvania,	1717.
Brendlinger,	Pennsylvania,	1717.
Gap,	Pennsylvania,	1718.

PRODUCTION OF CORUNDUM AND EMERY IN 1906.

Corundum and its modification, emery, furnish the best natural abrasive known, except diamond, the use of which is limited by its high price, and the purer forms of corundum make an abrasive material which is probably the equal of any of the artificial abrasives. The abrasive quality of emery is determined by the quantity of the iron ore (magnetite or hematite) mechanically mixed with the corundum, being better as the percentage of iron is smaller. The production of these minerals in the United States is limited by the scarcity of the supply and by competition with Canadian corundum, Asia Minor emery, and artificial abrasives.

Corundum has been mined in the United States for abrasive purposes in North Carolina, Georgia, and Montana, but with the exception of a small quantity from Kansas, the whole production in 1906 came from Massachusetts and New York. The output for 1906 amounted to 1160 short tons, valued at $44,310, as against 2126 short tons, valued at $61,464, in 1905.

The demand for corundum and emery and other abrasives, natural and artificial, is reported by Douglas B. Sterrett, geologist, United States Geological Survey, in an advance chapter from "Mineral Resources of the United States, Calendar Year 1906," which is now ready for distribution by the Survey.

*Granberry, J. H. The Schuyler Mine. Journal Franklin Institute, 164, 1907, 13-28, 217-223.

Section of Photography and Microscopy.

(Stated meeting held Thursday, March 12, 1908.)

Brief Notes On the Early History of Photography in Philadelphia.

By Alfred Rigling, Librarian of the Institute.

In the autumn of 1839, accounts began to appear in the newspapers and magazines of the United States of the achievements of Louis Jacques Mandé Daguerre, in the field of photography.

One of the earliest notices of the advance in this art was communicated to the editor of the United States Gazette, by Alexander Dallas Bache, and reprinted in the *Journal* of the Franklin Institute for September, 1839. This was followed in the October number by a brief note extracted from the Mechanics' Magazine, London, and in November there appeared a translation, by Prof. John F. Frazer, of the original article of Daguerre.

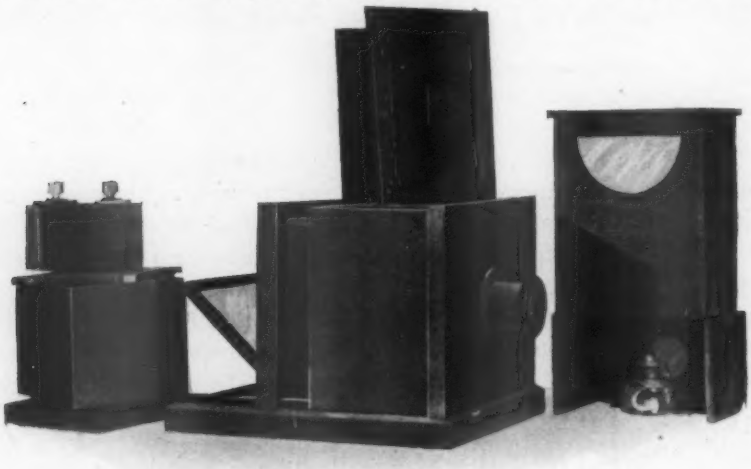
This contained a very full description of the process with illustrations of the apparatus necessary to carry out the various stages of the operation.

Soon after news reached Philadelphia of the latest developments in the art of picture-taking Joaquim Bishop, a chemical instrument maker, then living at 213 Cherry Street, and assistant to Dr. Robert Hare, Professor of Chemistry at the University of Pennsylvania, constructed three cameras after the description of Daguerre. One of these came into the possession of Dr. Paul Beck Goddard, an associate of Dr. Hare at the University, another was turned over to Justus Saxton, a mechanic connected with the United States Mint, and the third became the property of Robert Cornelius, a sheet metal worker, who was in business at 176 Chestnut Street.

Dr. Goddard soon discovered the use of bromine as an accelerator, thereby reducing the time of exposure and making portraiture possible commercially.

To Robert Cornelius belongs the credit for having brought to perfection the making and polishing of silvered copper plates upon which the photographs were taken.

As is always the case with new discoveries, so there were in Philadelphia in those days, the scoffers, and among them was a physician living near Twelfth and Arch Streets, who laughed at the idea of copying objects with the aid of sunlight. He soon had excellent reasons for changing his mind, and at the time of his



Sensitizing outfit Camera and plate holder Developing box

Dauguerreotype camera and accessories made by Joaquim Bishop, 1839.
Presented to the Franklin Institute by Dr. Paul J. Sartain.

death, in 1854, he was one of the ablest writers on the subject of photography in the United States.

Dr. Goddard lived on Ninth Street below Market, and one of his first pictures was a view, from the window of his home, of the University buildings on the opposite side of the street—the site of the present post office.

Justus Saxton also began taking pictures, and among his earliest attempts were views of the old Arsenal and the High School.

The first portrait was made in 1839, by Prof. Walter R. Johnson, a scientist of much note, who is best known for his elaborate report on American Coals, made to the Navy Department and published in 1844.

Dr. John E. Parker, a dentist, living at 411 Mulberry Street (now Eleventh and Arch Streets), surpassed all others as a photographer of out-door views, street scenes and buildings; he also did much toward perfecting the photographic apparatus of those days.

The tradition is that Dr. Goddard communicated to Robert Cornelius his experiences with bromine, and its effects upon the time of exposure, and that the latter gave up his metal business and established the first photographic studio, at Eighth Street and Lodge Alley, near Chestnut Street; the first professional picture being that of John McAllister, the optician.

It has not been possible to find any record in the Philadelphia directories of the Cornelius daguerreotype studio, and it is therefore not likely that he was in business for any great length of time.

It is stated that he was succeeded by W. & F. Langenheim. These gentlemen opened a studio at 26 and 27 Exchange Street, during the year 1842, or early in 1843, and became the leading photographers in Philadelphia, and also attained an international reputation.

A philosophical instrument maker, A. Mason, by name, produced an excellent copy of an engraving by the light of a small gas burner. This, it is said, was the first picture ever taken by artificial light.

Mason also succeeded in making daguerreotypes on steel.

Dr. Goddard's medical practice and his duties at the University prevented him from continuing his experiments with the daguerreotype, and he sold his camera and accessories to Mr. John Sartain. Later they came into the possession of the late Mr. Samuel Sartain, for many years treasurer of the Institute.

Through the kindness of Dr. Paul J. Sartain, this apparatus has recently been deposited in the Institute and forms an interesting addition to the collection of historic models.

It consists of a sensitizing box, a camera and a developing box.

Briefly described the process is as follows:

After the silvered copper plates have been thoroughly cleaned with nitric acid, they are ready for the sensitizing box. Here they are exposed to the vapor of iodine, and when uniformly coated they are placed in the camera.

This piece of apparatus resembles the modern studio camera in

a slight degree. It has no bellows; the rear portion of the box fits snugly into the front portion and slides freely back and forth. The inside of the rear portion is lined with black velvet and the front portion is painted black.

An achromatic single lens, brass mounted, with fixed diaphragm and metal cover is fitted into the front of the box.

Behind the ground glass is a mirror, hinged at the bottom, which drops outward and may be fastened at an angle of forty-five degrees. By looking down into this mirror we see the object which it to be photographed, in the proper position, right-side up.

After focusing, the sensitized plate takes the place of the ground glass, as in the modern camera, and the side of the plate holder toward the lens is released by loosening a button, and allowed to drop down and rest on the bottom of the camera, thereby uncovering the plate.

Everything is now in readiness for the exposure, which is done by opening the metal cover of the lens.

M. Daguerre, in his original communication to the French Academy, stated that the time of exposure varied, at Paris, from three to thirty minutes, according to the season of the year and the time of day.

After exposure, the plate holder is closed by means of a strap, which projects through a slot in the holder, and withdrawn from the camera with its contents.

The plate is then ready for the third operation. It is placed into the box arranged for development, and exposed to the vapor of mercury.

The small metal dish at the bottom of the box containing the mercury is heated by a spirit lamp.

When the temperature reaches 140° F. the lamp is withdrawn and in a short time development begins; it can be observed through the glass in the box.

When the temperature of the mercury has fallen to 113° F. the plate is finished and ready to be fixed. This is accomplished by dipping it into a weak solution of hyposulphite of soda. It is afterwards washed in clean water and then put under glass for permanent preservation.

During the sixty-eight years that have passed, many improvements have been made in camera accessories; devices for focusing

and adjusting, diaphragms and shutters, plate-holders and lenses; the design of the camera remains the same excepting that bellows have been substituted for the telescopic arrangement.

On the other hand, rapid strides have been made in the processes connected with picture-making, and the daguerreotype was in a short time succeeded by the many modifications, among the earlier being the ambrotypes and the opalotypes.

Much of the early history of photography in Philadelphia has been forgotten, and only a bare mention of the facts can be found in the works of reference.

It is to be hoped that a complete sketch may soon be written and that the names of the more recent investigators, who have labored so diligently, may be permanently recorded.

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Stahl und Eisen. Gesammt—Inhaltsverzeichnis der Jahrgaenge 1-26 (1881-1906). Im Auftrage des Vereins Deutscher Eisenhuettenleute. Bearbeitet von Franz Liebetanz, Duesseldorf. Verlag Stahleisen (m. b. H.) 8vo. 370 pages. Half leather.

Every student and investigator in the field of metallurgy, who has a working knowledge of the German language is familiar with that excellent publication, "Stahl und Eisen," which has appeared regularly during the past twenty-seven years, under the direction of the Society of German Iron Manufacturers. In the volumes may be found the records of progress in all the fields of metallurgy, though the iron and steel industries receive special attention. The set is a store-house of information for the metallurgical worker. To make the series still more valuable it is now supplied with an index which covers the subjects, titles and authors of all the volumes from the beginning, in 1881, to the end of 1906. The preparation of this index was undertaken by Mr. Liebetanz, and the work seems to have been done carefully. The publication of this index will make the file of "Stahl und Eisen" more useful for reference than it has been heretofore.

A. R.

Erratum.

April number, 1908, Vol. CLXV, page 262, tenth line from the bottom, after the figures "1855-68," insert following the comma, "58 respectively;" page 297, fourth line from top, for "1868-69" read "1866-69."